

Knowledge network management and territorial innovation
systems – a comparative analysis of science parks

Dissertation

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List of abbreviations

AdW – Academy of Science (of the GDR)

Agency IDEA – Agencia de Innovación y Desarrollo de Andalucía

BMBF – Federal Ministry of Education and Research

BMWi – Federal Ministry of Economic Affairs and Energy

CABIMER – Andalusian Molecular Biology and Regenerative Medicine Centre

CEADE – Andalusian Centre of Business Studies

CIC - Chamber of Industry and Commerce

cicCartuja – Research Centre of Isla de la Cartuja

CITAndalucía – Innovation and Technology Transfer Centre of Andalusia

CSIC – Spanish National Research Council

CTA – Technological Corporation of Andalusia

DLR – German Aerospace Center

e.g. – for example (Latin: *exempli gratia*)

EOI – School of Industrial Organisation

EU – European Union

FBH – Ferdinand-Braun-Institut, Leibniz-Institut für Hochfrequenztechnik

FIDETIA – Fundación para la Investigación y el Desarrollo de las Tecnologías de la Información en Andalucía

Fraunhofer FIRST – Fraunhofer Institute for Computer Architecture and Software

GDR – German Democratic Republic

HEI – Higher education institution

HU-Berlin – Humboldt-Universität zu Berlin

HZB – Helmholtz Zentrum Berlin

i.a. – amongst others (Latin: *inter alia*)

i.e. – that is (Latin: id est)

IASP – International Association of Science Parks and Areas of Innovation

KNM – Knowledge network management

MNE – Multinational enterprise

NDA – Non-disclosure agreement

NTBF – New technology-based firm

OECD – Organisation for Economic Co-operation and Development

OTRI/STCE – Oficina de Transferencia de Resultados de Investigación / Secretary of Knowledge Transfer and Entrepreneurship of the University of Seville

PCA – Principal component analysis

PINTA – Proyecto de Investigacion sobre Nuevas Tecnologias en Andalucia

PR – Public relations

R&D – Research and development

RETA – Andalusian Technology Network

SME – Small and medium-sized enterprise

STP – Science and Technology Park

TSB – Technologiestiftung Berlin

TIS – Territorial innovation system

TTO – Technology transfer office

WISTA-MG – WISTA-MANAGEMENT GmbH

ZIM – Zentrales Innovationsprogramm Mittelstand

1. Introduction

“The most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning.” (Lundvall, 2010: 1)

1.1 Initial situation and objectives of the dissertation thesis

It is widely recognized in the academic literature that knowledge is the central element for a firm's competitiveness and ability to innovate and grow in today's globalizing learning economy.¹ In addition to the internal production of new knowledge, especially a company's ability to collaborate, and to find, access, absorb and exploit external knowledge has become the central determinant for its commercial success. The dynamic, non-linear model of innovation emphasizes interactive learning, i.e. the interactive process of knowledge production, appropriation and distribution, as the basis of innovation.² Subsequently, learning is understood as a predominantly interactive and socially embedded process, which involves a wide range of actors and sub-systems (Lundvall, 2010). The large variety of actors involved in processes of interactive learning is also expressed in the concepts of triple helix (Leydesdorff & Etzkowitz, 1996), quadruple helix (Etzkowitz & Leydesdorff, 2003), and quintuple helix (Carayannis & Campbell, 2010).

Important for economic geographers, the exchange of tacit, experience-based knowledge (Polanyi, 1966), which is assumed to be fundamental for learning and innovation, requires face-to-face interaction favouring the local and regional scale over others. As a consequence, and also due to the observed economic success of innovative regions, such as, Third Italy (Bagnasco, 1977), Silicon Valley (Saxenian, 1994) and Hollywood (Storper &

¹ The terms learning economy (Lundvall, 1992) and knowledge-based economy (OECD, 1996) are generally used synonymously as they commonly stress knowledge as the most important resource and learning as the most fundamental activity for a competitive advantage in the globalizing economy. However, they slightly differ as the term knowledge-based economy puts a distinct emphasis on the differentiation between different degrees of high-, medium- and low-tech industries (Asheim & Coenen, 2005). Also, the term knowledge economy is often used synonymously to the two other terms. However, they are not defined alike. The term knowledge economy was established earlier and underlines the composition of the labour force as an input factor in the production process (Cooke & Leydesdorff, 2006).

² The dynamic process of innovation underlines the fundamental importance of various actors (e.g. suppliers, customers and academia), as well as multiple loops of feedback and reproduction of knowledge. In contrast, the traditional linear process of innovation stressed technical change and innovations as a result of scientific and research efforts being directly transferred to the firm and, then, introduced to the market (Lundvall, 2010).

Christopherson, 1987), various theoretical concepts have been developed that underline the facilitative role of geographical proximity for knowledge spillovers and interactive learning – the most prominent examples being the innovative milieu (Aydalot, 1986; Camagni, 1991), Porter's cluster (Porter, 1990), learning regions (Florida, 1995, Morgan, 1997), new industrial districts (Scott, 1988; Markusen, 1996) and territorial innovation systems (Lundvall, 1992; Braczyk et al., 1998).

Also, policy makers have been paying increasing attention to specific places and regions as designated sites of innovation and competitiveness. For the triple helix (industry-academia-government) in particular, a wide spectrum of technology and innovation policies have aimed at fostering and even planning interaction between science and high-technology industries in order to increase regional economic growth, competitiveness and innovativeness (Sternberg, 1995).³

In this respect, science and technology parks (STPs) have become a prominent instrument as planned seedbeds of innovation (Felsenstein, 1994) in regional economic development policy. Similar to the theoretical concepts of the spatial innovation systems literature, STPs are typically linked to the geographical co-location of the triple helix, i.e. firms and scientific institutions operating in similar or related sectors and technology areas, respectively, and a certain socio-institutional thickness. Consequently, this setting of geographical proximity, related variety (cognitive proximity) and "institutionalized high-trust environments (institutional and social proximity)" (Fitjar & Rodríguez-Pose, 2011: 1248) seeks to thrive personal interaction and, in turn, the diffusion of tacit knowledge among co-located knowledge organizations (Boschma, 2005; Fitjar & Rodríguez-Pose, 2011). However, many STPs reveal shortcomings in the anticipated effects of localized interaction and knowledge spillovers promoting interactive learning and, in turn, also in their expected role as important organizational links driving regions' innovativeness (e.g. Quintas et al., 1992; Vedovello 1997; Fukugawa, 2010).

In addition, increasing theories and empirical evidence for the equivalent importance of local and non-local connections as roots of knowledge diffusion and innovation, which is, for example, represented in the local buzz and global pipelines dichotomy (e.g. Bathelt et al., 2004; Wolfe & Gertler, 2004; Trippel et al., 2009), have led to the critical assessment of

³ While industry refers to companies, academia refers to higher education and public sector research institutions (Polt et al., 2001). In this dissertation thesis, the terms R&D institution and non-university research institution are used synonymously.

the role of 'proximity' in knowledge interaction and learning in the more recent academic discussion.⁴

Especially the French school of proximity dynamics (e.g. Torre & Gilly, 2000; Gallaud & Torre, 2005; Torre & Rallet, 2005) and Boschma (2005), among others, has challenged the traditional perception that spatial proximity is a necessary and sufficient criterion for knowledge interaction and interactive learning to take place. Instead, the significance of the multi-dimensional character of proximity, integrating non-spatial proximity to the strict geographical interpretation of proximity, is strongly advocated for the multi-scalar geography of knowledge sourcing and knowledge interaction.

In addition to knowledge interaction based on direct relations, knowledge diffusion between actors also results from indirect links facilitated by governance and intermediation (Nooteboom, 2003). Thus, a firm's capability to manage both internal knowledge generation and the access to external knowledge (knowledge management) finally determines their innovativeness (Ibert & Kujath, 2011). Yet, few studies have adapted the concept of knowledge management from the organizational learning literature to spatially defined innovation systems (e.g. Harmaakorpi & Melkas, 2005).

Thus, the innovative approach of this doctoral thesis is the combination of theoretical concepts drawn from economic geography, namely STPs and the proximity framework, and from the organizational learning literature, namely knowledge management. In combination, I aim to determine the applicability of knowledge network management systems for the organization of multi-dimensional proximity in order to foster cross-institutional knowledge relations in STPs and external to STPs.

In response to the recent developments of the specific interrelated strands of research, I aim to determine (a) the quality, structure and geography of STP resident firms' linkages to scientific knowledge sources in their pursuit of learning and innovation, as well as (b) the driving factors and criteria in terms of specific types of proximity behind successful link creation and knowledge interaction with scientific institutions on different geographical scales. Furthermore, I examine (c) to what extent firm-specific as well as external channels and platforms including STP-related knowledge network management systems affect resident firms' knowledge interaction with academia on the local and extra-local scale. I address

⁴ The location paradox reflects the global and local dialectic of, on the one hand, the global exchange of information and knowledge based on ICT technologies and global mobility, and, on the other hand, of the consistent trend of geographical agglomeration of especially knowledge and technology-intensive industries due to the proximity to markets, availability of skilled labour, anticipated knowledge spillovers and need for personal interaction in interactive relations, among others (Malecki, 2000; Anttiroiko, 2004).

these topics by exploring the geographical sources of innovation and related influencing factors of technology-oriented resident firms in two science and technology parks in Berlin (Germany) and Seville (Spain).

The following research questions are at the centre of this dissertation thesis:

1. What knowledge relations to academia are evident for the STP resident firms in the two science parks?
2. What types of firm-centred knowledge networks to academia can be identified?
3. What are the influencing factors enabling and driving knowledge interaction with academia in the STP and external to the STP? Which firm-specific and external channels and platforms enable and promote the formation and realization of STP resident firms' knowledge relations to academia on the local and extra-local scale?
4. Which dimensions of proximity matter in a firm's knowledge relations with academia?
5. To which extent do knowledge network management systems in STPs create and organize proximity to stimulate industry-academia knowledge relations?

As a result of this work, I aim to add new aspects to the “soft architecture of learning” (Thune, 2009: 9) by developing specific policy recommendations for the design and orchestration of effective knowledge network management systems in STPs. The policy implications aim to address STP developers and managers in particular, as well as additional stakeholders and policy-makers involved in the development and implementation of regional innovation policies.

The practice-oriented approach of this dissertation thesis is heavily influenced and motivated by the research project's integration in the EU INTERREG IVC project Knowledge Network Management in Technology Parks (Know-Man), as well as my professional experiences as a consultant in regional economic development and STP management.

1.2 Structure of the thesis

This thesis is organized as follows. In Chapter 2, the theoretical framework of this dissertation thesis is presented. Firstly, I introduce the concept of science and technology parks, which motivated this research project throughout (primary statement of problem). The chapter illustrates the evolutionary development of STPs from being first experiments in establishing industrial production in the vicinity to universities in 1950s California to universally implemented localities of learning by design in order to promote technology-based entrepreneurship and innovation. Furthermore, it describes the effects created by STPs, as

well as important challenges in regard to its anticipated role in the knowledge-based economy (see Chapter 2.1). Subsequently, I elaborate on the academic discussion of the proximity framework in knowledge creation and interaction, which puts a fundamental emphasis on non-spatial natures of proximity in addition to geographical proximity (see Chapter 2.2). As an additional theoretical approach, the concept of knowledge management, derived from the literature of organizational learning, is introduced and applied to the context of industry-academia knowledge relations in local and regional innovation systems (see Chapter 2.3). In Chapter 2.4, I combine the theoretical approaches highlighted and outline the research questions of this thesis' analysis.

Chapter 3.1 presents the two science and technology parks Berlin-Adlershof and Seville-Cartuja, where the knowledge relationships of resident firms are examined. In addition, emphasis is put on the description of the knowledge network management (KNM) systems at the two STPs. Subsequently, Chapter 3.2 introduces the mixed methodology of the empirical analysis that was implemented at the Berlin-Adlershof and Seville-Cartuja science and technology parks.

The results of the analysis are presented in Chapter 4. Firstly, the structure and geography of resident companies' interactive ties to academia are examined – testing also for the validity of the coexistence of local and non-local knowledge relations. The identification of distinct types of firm-specific knowledge networks to academia seeks to determine the specific entry and driving channels including KNM instruments that facilitate the formation and realization of these interactive ties. Subsequently, I explore the configuration of multifaceted proximity responsible for STP resident firms' successful link creation and knowledge interaction with scientific institutions. Against this background, I analyse the influence of proximity-organizing KNM instruments accessible in the two STPs.

Finally in Chapter 5, I draw conclusions and make policy recommendations on how knowledge network management systems in STPs can organize 'proximity' (i.e. specific configurations of non-spatial and spatial proximity) between businesses and academia more effectively to meet related expectations of STPs being seedbeds of innovation and knowledge-creating nodes in the globalizing knowledge-based economy.

Figure 1 shows the structure and content of this dissertation thesis in conjunction with the applied methodology. In the Appendix, I provide an overview of the technology companies interviewed in the Adlershof and Cartuja science parks (Table A1). Moreover, it includes the questionnaires and interview topic guides used for the combined standardized and semi-standardized interviews in the two science parks (Figures A1 and A2).

Figure 1: **Structure and methods of the dissertation thesis**

	Content	Method mix
Theory	Theoretical concepts to knowledge relations between science park resident companies and scientific institutions <ul style="list-style-type: none"> • Introduction to the concept of science and technology parks as planned seedbeds of innovation (definition, evolution of the STP model, effects and current challenges) • Proximity framework in knowledge interaction and learning • Knowledge management and its applicability to local and regional innovation systems in order to activate and to steer industry-academia linkages 	Literature review Secondary data analysis Expert interviews
Empirical analysis and results	Science and technology parks in Berlin and Seville <ul style="list-style-type: none"> • Selection of the two STP examples • Analysis of the Adlershof and Cartuja science parks (development and tenant composition) • Description of the knowledge network management systems 	
	Empirical research methodology <ul style="list-style-type: none"> • Design and realization of standardized interviews • Conception and implementation of semi-standardized interviews 	
	Analysis of STP resident businesses' egocentric knowledge networks to academia <ul style="list-style-type: none"> • Strength and structure of local and non-local knowledge relations • Identification of distinct types of knowledge seeking companies • Exploration of influencing channels and settings of link creation and knowledge interaction Analysis of proximity configurations in STP resident firms' knowledge relations to scientific knowledge sources <ul style="list-style-type: none"> • Investigation of the function and interplay of non-spatial and spatial dimensions of proximity • Exploration of the systematic organization of proximity through KNM practices 	Quantitative analysis (standardized interviews, cluster analysis) Qualitative analysis (semi-structured expert interviews) Literature review
Policy	Conclusion of the key results regarding proximity configurations in STP resident firms' knowledge relations to scientific knowledge sources <ul style="list-style-type: none"> • Empirical evidence for distinct proximity dynamics in industry-academia knowledge relations • Enhanced understanding of the applicability of proximity-organizing KNM systems to coordinate and harness multi-scalar knowledge relations • Policy implications for the effective orchestration of KNM systems in STPs and other kinds of innovation habitats 	Interconnection of empirical results with the academic discussion Literature review

Source: Author

2. Theoretical background

This chapter presents the theoretical concepts applied in this thesis. Firstly, I introduce science and technology parks as planned seedbeds of innovation and prominent instruments in regional economic development, which are primarily based on geographical co-location of a variety of knowledge organizations (Chapter 2.1). In addition to the related objectives, I discuss the observed effects of STPs on regional economic development, businesses' economic and innovation performance and in particular localized knowledge interaction. Secondly, the theoretical concept of the proximity framework describes the distinct functions of spatial proximity, but in particular of diverse non-spatial dimensions of proximity in knowledge interaction and interactive learning (Chapter 2.2). As a third theoretical concept, the concept of knowledge management, widely used in the business management and organizational learning literature, is linked to the coordination of firms' knowledge relations to scientific institutions in the context of territorial innovation systems (TIS) and specific localities of learning such as STPs (Chapter 2.3). Ultimately, the theoretical and conceptual approaches used are combined to develop the analytical framework and the relevant research questions for this thesis (Chapter 2.4).

2.1 Science and Technology Parks as designated seedbeds of innovation

Territorial knowledge-based agglomerations, which refer to the geographical concentration of a diverse set of knowledge creating, adapting and exploiting entities from research and industry, have become a popular planning instrument in regional economic policies (Kühn, 2003). Motivated by successful (but interestingly not intentionally planned) high-tech regions, such as the Third Italy (Bagnasco, 1977) and Silicon Valley (Saxenian, 1994), policy makers around the world aim to develop similar seedbeds of innovation (Hu, 2007).⁵ Linked to theoretical concepts such as the innovative milieu (Aydalot, 1986) and industrial clusters (Porter, 1990), intentionally planned localities of learning, such as science and technology parks, have become popular policy instruments to spur regional technology and innovation-driven economic development based on industry-academia knowledge transfer and learning (Kühn, 2003; Hommen et al., 2006).

⁵ Very successful high-tech regions such as Silicon Valley are often based on unique regional and national contexts. As a result, their replication and the adoption of detected success factors remain difficult (Hommen et al., 2006).

2.1.1 Science and Technology Parks: Definition, objectives and central functions

Overall, the typology of high-technology agglomerations ranges from large-scale high-tech regions, to high density-related and urban-like knowledge cities, technopoles and science parks to microhabitats such as small-scale business incubators. Accordingly, distinct geographical sizes, in which high-technology and knowledge-based activities are organized, define the different concepts. The various types also differ by their inherent functions. Classical science parks and technopoles are usually solely based on the spatial co-location of technology firms and public scientific institutions, whereas science cities, knowledge cities, as well as creative and innovative districts are typically characterized by an enhanced urban setting in conjunction with mixed use of work, living and recreation, as well as other social and urban amenities (Anttiroiko, 2004; Kühn, 2003; Brookings, 2014). Table 1 provides an overview of the different types of high-technology and knowledge agglomerations distinguished by different geographical scopes, involved actors and functions.

Table 1: Typology of high-technology and knowledge agglomerations and centres

Types	Names	Major actors	Functions / goals	Examples
High-tech microenvironments	- Incubator - Accelerator	- Growth-oriented firms, start-ups and spin-offs	- Quick take off and growth of IT firms	- International Business Incubator in San Jose
Research centre	- Research centre - Innovation centre	- Research institutes, R&D units, new businesses	- High level of expertise	- Centres of excellence in Finland
University campus		- Public or private universities and related departments	- Research and education - Park-like self-contained campus	- Universities in North America, University of Dortmund
High-tech industrial park	- Industrial park - High-tech park	- Government and industry	- Promote industrial activities	- High-tech industrial zones in China
Science park	- Research park - Technology park - Technopark	- Technology-oriented firms, government, university and research institutes	- Industrial growth - Technology growth	- Mjärdevi and Cambridge science parks
Technopolis	- Technopole	- Local government, private firms, research institutes	- Regional development and industrial decentralization	- Technopoles in France and Japan
Science city	- Science town	- Government, research institutes	- Higher level of scientific excellence in urban form	- Daedok Innopolis, Kista Science City, Tsukuba Science City, STP Adlershof
Intelligent city	- Smart community - Learning city	- City government and actors in local community	- Advantages through knowledge systems and	- European digital cities (e.g. Antwerp, The Hague etc.), Intel-

Types	Names	Major actors	Functions / goals	Examples
	- Knowledge city		virtual innovation milieu	Island of Singapore
Area of innovation	- Innovation district - Urban knowledge park - Urban lab	- Technology-oriented firms, research/education, government, general public/talent	- Urban setting - Open innovation systems - Entire technology development chain	- 22@Barcelona, South Waterfront Innovation District in Boston, Cambridge's Kendall Square
High-tech city	- Technocity - High-tech metropolitan area	- Private firms and urban innovation milieu	- High value adding activities	- Tokyo, Paris, London, Stockholm, San Jose
Large high-tech complex	- High-tech region - Learning region - Innovative region - Knowledge-based urban landscape	- High-tech firms and regional production and innovation networks	- Production, innovation and learning for global success	- Silicon Valley, Boston Route 128, Baden-Württemberg, Research Triangle

Source: Author based on Kühn (2003), Anttiroiko (2004), European Commission (2013) and Brookings (2014)

Science and technology parks have been the subject of extensive academic research in the past. Nonetheless, there is no universally accepted definition of STPs. In the academic literature and in policy discussions similar terms are utilized; research parks, science parks, science and technology parks, high-tech parks, technopoles and science cities, among others (Link & Link, 2003; Anttiroiko, 2004; Fukugawa, 2006).⁶ Nevertheless, the terms science park, technology park, research park and science and technology park are used interchangeably in the literature (Anttiroiko, 2004).⁷ Interestingly, the term science park is more prevalent in Europe, while the terms research park and technology park are more popular in the USA and Asia, respectively (Link & Scott, 2011). This thesis applies the terms science park as well as science and technology park synonymously.

Among the different definitions, a number of common objectives and characteristics of science and technology parks as property-based ventures are underlined. All concepts of STPs underscore an economic and technological development initiative that aims to facilitate the transformation of scientific knowledge and research results to marketable technologies, the creation of new high-technology firms and the growth of existing technology-oriented businesses (Anttiroiko, 2004).

One strand of objectives and anticipated results linked to the development of STPs is based on the expected generation of various kinds of externalities due to geographical co-location (Westhead & Storey, 1994), of which underlying mechanisms are closely linked to the territorial innovation approaches discussed in the literature, for example, industrial district (Marshall, 1920), innovative milieu (Aydalot, 1986) and Porter's cluster (Porter, 1990). Accordingly, the geographical proximity of technology-oriented and knowledge-based firms, as well as universities and R&D institutions at STPs, is expected to lead to reduced transaction costs and uncertainty (i.e. risks concerning the capability and reliability of potential cooperation partners). As a result, it facilitates the development of informal and formal interaction, in terms of the sharing of tacit knowledge, the transfer of academic ideas and technology, the mobility of talent, as well as the accessibility to scientific resources (Quintas et al., 1992; Siegel et al., 2003b; Mian et al., 2012). Furthermore, regular face-to-face contacts and the development of trust in inter-personal relations between researchers and

⁶ Multiple scholars have argued that a universal concept of STPs is not possible because motivations and objectives of STPs are strongly related to their distinct regional contexts, in terms of geography, political system, society and economy (Phan et al., 2005; Hommen et al., 2006).

⁷ Although the terms science park and research park are often used synonymously, specific differences are underlined in the literature. The former primarily focuses on basic research and its commercialization based on the creation of university-industry linkages. The latter emphasizes the focus on applied research and its application to industry in particular (Anttiroiko, 2004).

entrepreneurs are additional vital success criteria facilitated by spatial vicinity of STP resident organizations. Personal interaction and trust are particularly critical for the exchange of tacit, i.e. implicit and experience-based knowledge, which is considered fundamental in technological innovations (Fukagawa, 2006). Expected results of the multi-faceted knowledge externalities comprise the creation of novel ideas and technological innovation, the development of new technology-based firms (NTBFs) as well as enhanced regional economic growth in research-intensive and high-technology industries in general (Hommen et al., 2006). Additional positive externalities associated with the geographical concentration of a diverse set of knowledge-creating organizations in STPs are high talent mobility, improved availability of skilled talent, as well as enhanced access to clients and suppliers (Siegel et al., 2003b; Huber, 2011). Finally, STP resident firms also are expected to take advantage of certain image advantages due to the prestige and image of STPs – often strongly related to the presence of prominent universities and R&D institutions (Fukagawa, 2006; Anttiroiko, 2004).

The other strand of objectives and expected effects in regard to the development of STPs is connected to the active support and interface function of STPs. STPs as property-based initiatives are typically operated by a professional management organization. In addition to facility and real estate management tasks, the STP management takes over three important functions. Firstly, it offers NTBFs and technology-based SMEs a favourable and sponsored business environment, which enables them to overcome typical obstacles such as limited size, resources and experiences. In this respect, STPs help to reduce related real estate, service and overhead costs. Usually, the specialized infrastructure provided (e.g. incubators, technology centres) comprises flexible and subsidized workspaces, as well as shared resources. Secondly, in conjunction with the specialized support infrastructure, STPs typically also assist in the business development of innovative start-ups and SMEs by providing access to below market rate value-added business services in a variety of topics, for example, start-up support, technology and knowledge transfer, internationalization, financing, legal assistance and intellectual property protection, technology monitoring, as well as marketing (Siegel et al., 2003b). Thirdly, the STP management also acts as an active gatekeeper in promoting informal and formal interaction between resident firms and co-located scientific institutions. Related services and activities comprise, for example, informal contacts, communication about scientific institutions' resources and skills, development of networking platforms, as well as the creation of informal meeting places in terms of public spaces and recreational facilities etc. Moreover, STP managers can act as formal intermediaries to minimize uncertainty for their resident organizations. For example, they can legitimize resident firms' activities and contribute to an enhanced reputation helping

them to gain access to critical resources and knowledge of scientific organizations, but also other businesses, financial organizations and clients (Westhead & Batstone, 1999; Siegel et al., 2003b).

This broad set of objectives, functions and responsibilities is also reflected in the criteria allocated to STPs by the International Association of Science Parks and Areas of Innovation (IASP):⁸

- Management by a specialized management team,
- Support in economic growth of the community,
- Promotion of innovation and competitiveness of resident firms, universities and research organizations,
- Stimulation and management of exchange and transfer of knowledge and technology between resident firms, universities, research organizations and markets,
- Assistance in creation and growth of innovative companies through incubation and spin-off services,
- Provision of value-added services in conjunction with high quality facilities and infrastructure (IASP, 2016).⁹

In sum, there is a consensus in the academic literature and in policy discussions that the traditional STP model is characterized by the spatial agglomeration of three major components that are strongly interrelated in knowledge exchange and innovation activities – also referred to as triple helix¹⁰:

1. A scientific component represented by universities, non-university research institutions, R&D laboratories as well as other technical and educational entities, which develop and diffuse knowledge and technology,

⁸ Other national associations of STPs, for example, the US-based Association of University Research Parks (AURP), United Kingdom Science Parks Association (UKSPA) and the German Association of Innovation, Technology and Business Incubation Centres (BVIZ), have also underlined similar key criteria of STPs in terms of objectives and functions (AURP, 2016; UKSPA, 2016; BVIZ, 2016).

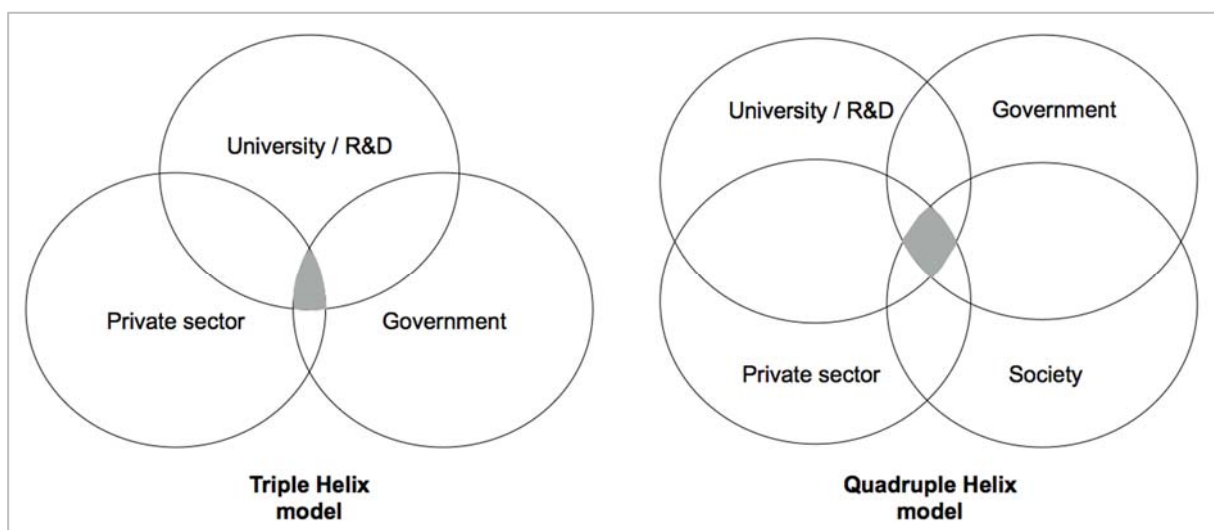
⁹ For a few years now, IASP has been utilizing areas of innovation as the overall term for geographically constituted innovation habitats, of which science and technology parks are a specialized type. In 2012, the IASP identified 362 STPs in the European Union (European Commission, 2013).

¹⁰ The triple helix model emphasizes the multi-faceted interdependencies between the private sector, universities and R&D centres, as well as public administration in RIS and TIS. The concept underlines the major role of universities as knowledge-hubs in the knowledge-based economy. The public sector is particularly responsible for the supply of public infrastructure, financial funds, as well as innovation management-related resources and support services (Leydesdorff & Etzkowitz, 1996, Etzkowitz & Leydesdorff, 2000).

2. A productive component represented by complementary technology-oriented and innovating companies, which are also able to diffuse and absorb knowledge and transform it into innovative technologies and marketable solutions,
3. A structural component, which is characterized by specialized (public) support services in entrepreneurship, financing, technology and commercialization, internationalization, talent, as well as knowledge and technology transfer (Hommen et al., 2006).

A fourth component, society and the general public, has been gaining relevance in the dynamic model of innovation. The increasing role of the civic society as sophisticated end-users and skilled talent as a critical factor for knowledge creation and innovation is coined in the concept of the quadruple helix.¹¹ By featuring distinct urban functions, this component is addressed more strongly in modern STPs, knowledge cities and areas of innovation (Kühn, 2003; European Commission, 2013). Figure 2 illustrates the two helices and related subsystems.

Figure 2: **Triple and quadruple helices and related subsystems**



Sources: Based on Carayannis & Campbell (2009), Leydesdorff (2012), Carayannis et al. (2012)

¹¹ The quadruple helix model is an extension of the triple helix concept. In addition, it emphasizes the augmenting importance of the society in increasingly dynamic and complex innovation processes in the knowledge-based economy. On the one hand, the civil society represents the sophisticated end-users, who continuously demand new and innovative technological solutions, products and processes. On the other hand, skilled talent is central to create new knowledge and generate innovation. Thus, the quadruple helix model incorporates the increasing interrelation between technological and social innovation (Carayannis & Campbell, 2009; Dubina et al. 2012).

2.1.2 Evolutionary development of STPs: From classical university research parks to knowledge-creating nodes in the globalizing learning economy

The development of STPs, which started in the 1960s, is linked to the success of high-technology agglomerations in Silicon Valley, Boston Route 128 and the Research Triangle Park in North Carolina. The first university-owned industrial park, founded by Stanford University in 1951 (Stanford Industrial Park, which was renamed later Stanford Research Park), took an important role in the development of Silicon Valley in California (Anttiroiko, 2004).¹²

In the early 1970s, the first pilot university-driven research and science parks at Cambridge University and Heriot-Watt University in Edinburgh were opened in the United Kingdom. Additional British science parks, mostly with formal operational ties to universities, followed in the early 1990s. At about the same time, rather large-scale technopoles (e.g. Sophia-Antipolis) aimed to attract large high-technology firms and corporate R&D units, were developed in France, whereas in particular small-scale and incubator-led business innovation centres and technology centres catering to NTBFs and without necessarily strong ties to HEI were set up in Germany (Anttiroiko, 2004).

Since the 1970s and 1980s, STPs have become a popular instrument of regional and national economic development policies worldwide to serve as catalysts for industrial revitalization, high-technology growth and innovation. The growth of new high-technology industries, such as ICT and biotechnology, in the 1980s and 1990s further advanced this connection (Hansson et al., 2005). Since the 1960s, however, STPs have undergone several evolutionary stages. Three generational types can be identified.

1st generation STPs (established before and during the 1980s) are characterized as often stand-alone, park-like campuses with good quality infrastructure and facilities. Most STPs of this kind were associated with one or multiple local universities and HEIs. Their primary goal was to promote the transfer of knowledge between co-located HEIs and on-park firms in order to commercialize university-based research findings. However, these kinds of interactive ties were rather limited (Mian et al., 2012; European Commission, 2013).

Anchor R&D centres and universities also characterize the next generation of STPs (established during the 1990s). However, 2nd generation STPs became more involved in regional

¹² The first spatial agglomerations of high-technology industries observed in industrialized countries like the United Kingdom and the USA in the late 19th and early 20th century can be considered as the first seeds of STPs. Marshall (1920) coined this development in the concept of industrial districts (Anttiroiko, 2004).

economic development as their focus shifted to the assistance of NTBFs. In order to compensate for the NTBFs' typically scarce resources and experiences in business development, STPs increasingly built business incubators and innovation centres. Moreover, they began to offer basic business services in terms of start-up support, entrepreneurship training and access to finances themselves or through partnering with other regional stakeholders (e.g. seed capital funds and business angel networks). At the same time, STPs also took a stronger nodal position in the regional innovation system (RIS) overall. Driven by their resident firms' demands, STPs proactively built additional relations to regional universities, research centres and technology organizations. These non-local networks aimed to enable on-park firms to access multi-faceted technology and knowledge resources and, in turn, to stimulate innovation-driven entrepreneurship (Mian et al., 2012; European Commission, 2013). Thus, during this evolutionary stage, STPs evolved to "networked commercialization enablers" (Mian et al., 2012: 237).

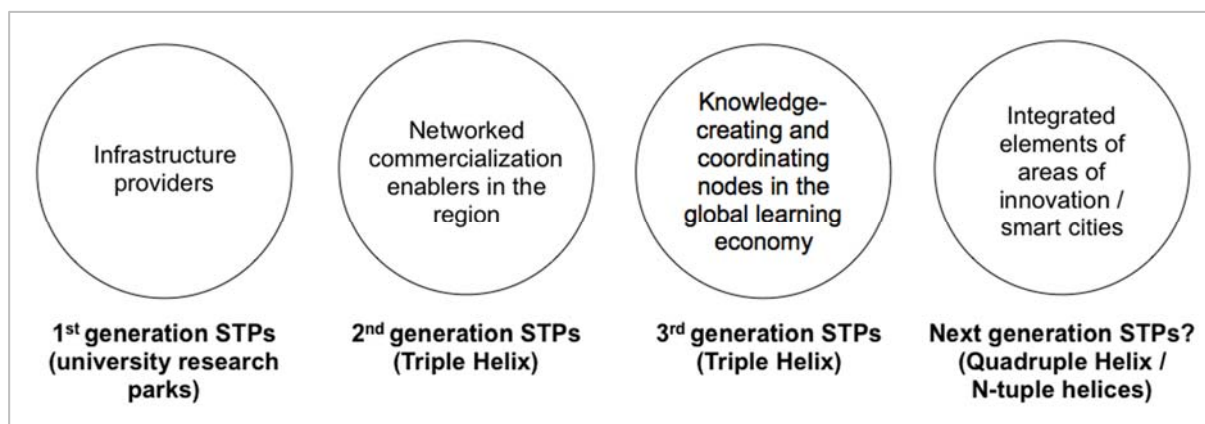
The key characteristics of 3rd generation STPs strongly correspond to the success criteria of successful 2nd generation STPs.¹³ In addition, these kinds of STPs emphasize the function of physical collaboration spaces and environments to stimulate interactive and collaborative processes of creativity and innovation. These collaboration spaces are made accessible to STP residents, but also to non-local knowledge sources such businesses, research organizations, suppliers and citizen in order to promote the transformation of knowledge into marketable outputs (i.e. products, services and processes) and to bring them to market (European Commission, 2013). Thus, science parks have recently evolved from merely infrastructure-providing physical locations in conjunction with basic management functions to service-oriented, permeable nodes within RIS, which primarily focus on innovation, commercialization and internationalization (Anttiroiko, 2004).

Thus, STPs are currently experiencing a revival because of their central function as organizational links and nodes in regional triple and quadruple helices. In today's knowledge-based economy, STPs take over a substantial, pro-active boundary-spanning role enabling and steering direct and indirect links to a large variety of local and non-local knowledge sources and related networks. Consequently, it is argued that the evolutionary process of STPs must continue in the direction of becoming active knowledge-creating and knowledge-coordinating institutions (Hansson, 2007; Fukugawa, 2010). Figure 3 summa-

¹³ In 2006, about 30 internationally leading STPs and related experts gathered at a conference in Manchester and defined the criteria for 3rd generation STPs. The conference resulted in the development of multiple principles for modern STPs, for example, connectivity and networking at all levels of the STP itself and its resident organizations, as well as development of environments to promote interaction, creativity and innovation (Allen, 2007; European Commission, 2013).

rizizes the distinct features of the different evolutionary steps of the STP model and its anticipated role in the future (see also Box 1).

Figure 3: **Evolution of the STP model**



Source: Author (based on European Commission (2013), Mian et al. (2012), Hansson (2007))

Box 1: **The next evolutionary step? Areas of innovation and innovation districts**¹⁴

Even more recently, areas of innovation incorporate an additional important evolutionary step in the development of STPs. In contrast to the concept of STPs, areas of innovation refer to extended geographical areas, such as entire city districts, cities and even regions. Furthermore, areas of innovation combine the complex network of knowledge organizations, specialized innovation infrastructures and public support institutions of the entire regional innovation system. Even STPs themselves are considered as just one element of areas of innovation. Additionally, distinct talent attraction and training programmes, innovation financing, as well as the integration of MNEs as potential partners for local start-ups, SMEs, HEIs and research institutions are underlined. As a result, areas of innovation aim to create an environment in which all different stages of the technology development chain, from idea generation through R&D, prototyping and demonstration, and finally to early commercialization, are concentrated and linked through multi-stakeholder platforms, collaborative networks, virtual forums and specialized interfaces. Thus, the term area of inno-

¹⁴ Multiple scholars have observed the global emergence of areas of innovation and innovation districts. They have been referred to as “creative, energy-laden ecosystems” (AIA, 2014: 2), “New Century City Developments” (Jaroff et al., 2009: 6) and “urban knowledge parks” (Bugliarello, 2004: 388). Hutton (2004) has considered such industrial inner-city clusters to “constitute important aspects of the spatiality of the New Economy” (Hutton, 2004: 90).

vation is often used synonymously with such terms as smart city, living lab and urban lab (European Commission, 2013).¹⁵

Similarly, innovation districts refer to primarily U.S. based examples of new inner-city development projects built upon the imperatives of spatial clustering, cross-industry interaction and open innovation systems of a broad set technology firms, R&D centres, universities and networks in diverse knowledge-intensive services and manufacturing sectors, for example, creative industries and life sciences, in order to propel knowledge creation, the commercialization of new ideas and, in turn, high-technology-based economic prosperity. Prominent examples are Cambridge's Kendall Square near the Massachusetts Institute of Technology (MIT) and Boston's South Waterfront Innovation District (Brookings, 2014; Lyndon B. Johnson School of Public Affairs, 2015; AIA, 2014).¹⁶

2.1.3 Evidence for value added contributions of STPs?

Due to the direct regional and local policy implications of STPs (i.e. economic and innovation policies), the academic literature has widely discussed STPs' multifaceted value added for residents firms, local scientific institutions and the region overall. Research on STPs predominantly focuses on 1) socio-economic effects of STPs (e.g. number of companies, employees, tax impact and innovation output), 2) on-park firms' performance (e.g. turnover, employment and innovation output in terms of patents and new products), and, finally 3) localized knowledge spillovers, in particular between co-located industry and academia.

In regard to the regional socio-economic impact of STPs, a large number of scientific studies and policy reports have broadly examined whether STPs achieve their role in the revi-

¹⁵ Examples for areas of innovation mentioned in the literature include 22@Barcelona, which is an urban redevelopment project of ca. 200 hectares of industrial land into an innovation district in the Poblenou district in Barcelona, Medion Valley that comprises ca. 300 organizations in life sciences and medical technologies in Denmark's Greater Copenhagen region, and the Skane region in Sweden (European Commission, 2013).

¹⁶ Three sub-types of innovation districts are observed in the USA. Anchor Plus Innovation Districts usually are clustered around an established anchor institution, for example, Kendall Square near the Massachusetts Institute of Technology (MIT) in Cambridge. Re-imagined Urban Areas refer to innovation districts, where underused space in the urban centre is revitalized. Boston's South Waterfront Innovation District is one example. Finally, Urbanized Science Parks are science parks that expand upon the classical suburban, rather isolated research park by increasing its urban density and adding additional resources and amenities. The currently modernized Research Park Triangle represents such type (Brookings, 2014; Lyndon B. Johnson School of Public Affairs, 2015). In addition, several metropolitan universities in the U.S. are currently building new innovation districts. Examples include Allston campus of Harvard University, Manhattanville Campus of Columbia University and East Baltimore's redevelopment of John Hopkins University (Ehlenz & Birch, 2014).

talization of regional and local economies, in particular regarding the creation of new jobs and technology-based firms, (e.g. University of Arizona, 2009; Handrich et al., 2008).¹⁷ Applied methods range from descriptive analyses to highly sophisticated analyses of multiplier effects.¹⁸

Furthermore, the asserted value to resident firms is related to distinct advantages over non-STP locations. In particular due to the spatial proximity to universities and non-university research institutions, STP resident firms are expected to show better performance in three dimensions in particular; 1) business performance (e.g. survival rate, growth, R&D productivity and innovative capacity), 2) knowledge spillovers, and 3) image advantages. Extensive research has been conducted to evaluate STPs' value to resident firms. Empirical studies (e.g. Quintas et al., 1992; Westhead & Storey, 1994; Vedovello, 1997; Siegel et al., 2003a; Link & Scott, 2003a; Fukugawa, 2006; Bilgiardi et al., 2006; Kulke, 2008; Yang et al., 2009; Chan et al., 2010) have covered STPs around the world, for example, Europe (e.g. Sweden, UK, Spain, Greece, Spain, Italy, Germany, Netherlands), North America (e.g. USA, Canada), Australia, as well as more recently Asia (e.g. Japan, China, Taiwan, Korea, Malaysia) and Africa (e.g. South Africa).¹⁹

Yet, clear positive results were only established for on-park firms' image advantages and an increased technology reputation associated with a STP location, prestigious address and social signalling.²⁰ Hence, the STP's image enhances the resident firms' credibility as high-technology firms, which in turn raises their ability to attract customers and cooperation partners (e.g. Monck et al., 1988; Westhead & Storey, 1994; Ferguson & Olofsson, 2004). In some cases, STP resident firms only seek to benefit from STP-related image advantages than other kinds of anticipated externalities, such as, localized knowledge

¹⁷ Table A4 in the Appendix provides an overview of exemplary studies of the regional economic impact of STPs.

¹⁸ The regional impact and multiplier analysis determines the total of direct, indirect and income-induced stimuli (e.g. employment, turn over, value added, tax income) on the regional economy resulting from the respective STP. For further details about the measuring methodology, for example, see WISTA-MANAGEMENT (2011b) and Handrich et al. (2008).

¹⁹ Table A5 in the Appendix provides an overview of empirical studies (non-exhaustive) that have examined the varying effects of STPs on resident companies. A large number of empirical studies focus on the analysis of on-park firms' performance in terms of R&D intensity, innovative outputs (e.g. patent activity, market launches of new products and services), growth (employment and turnover), survival/closure rates, as well as knowledge ties with scientific institutions. In order to examine STP's ability to function as seedbeds for new innovative firms and growth environments for high-technology SMEs, scholars have often used the so-called matched pair method. This methodology compares individual or multiple dimensions of business performance (e.g. employment and turnover growth, patent activity, new products) of on-park and off-park high-technology companies, *ceteris paribus*.

²⁰ Here, social signalling refers to transmitted signals of on-park NTBFs to other firms and organizations, conferring an enhanced reputation or legitimacy due to their STP location (Siegel et al., 2003b).

interaction. Royal Kaskoning (2011) has referred to these resident firms as image builders.²¹

In contrast, there is no clear empirical evidence for resident firms' augmented business performance (e.g. survival rate, closure rate, employment and sales, as well as innovative capacity) as a result of subsidized business environments, active business support services and facilitated access to scientific institutions.²² Some empirical studies of STPs in Sweden and Italy have found proof for higher growth of on-park firms' employment and sales, as well as higher survival rates (e.g. Löfsten & Lindelöf, 2001; Ferguson & Olofsson, 2004, Colombo & Delmastro, 2002). In addition, numerous scholars have underlined the STPs' positive role in enabling better innovation performances of resident firms, for example, measured in terms of patent activity (e.g. Siegel et al., 2003a, Squicciarini, 2008; Yang et al., 2009). As an illustration, on-park firms in the Hsinchu Science Industrial Park (HSIP) in Taiwan show higher R&D elasticity, i.e. impact of firms' R&D on their productivity performance, and thus, invest more efficiently in innovation (Yang et al., 2009).²³

Yet, a large number of studies that conducted matched-pair analyses of on-park and off-park businesses, for example, in the UK, Sweden and Israel, did not detect any clear evidence of significant positive effects and benefits of the STP location on resident firms' business performance (e.g. higher survival and growth rates). Also, no significant differences concerning the firms' innovative capacity (e.g. number of issued patents) and the ability to translate R&D investments into innovative outputs have been identified (e.g. Westhead 1997; Lindelöf & Löfsten, 2003, Siegel et al., 2003b).

Most importantly for this thesis, the academic discussion has also revealed mixed findings about STPs' impact on knowledge interaction and knowledge spillovers between resident firms and co-located academic institutions. On the one hand, several studies (e.g. Vedovello, 1997; Phillimore, 1999; Löfsten & Lindelöf, 2002) have found evidence for augmented

²¹ To describe the different motivations of firms to locate at STPs, Royal Kaskoning (2011) has applied the dichotomy of knowledge seekers and image builders.

²² However, Siegel et al. (2003b) have criticized that research findings derived from empirical studies of firms in single STPs or a small number of STPs are characterized by several limitations. For example, small firm samples do not represent the entire population of firms in STPs. Moreover, other studies have not matched their results with a control group of equivalent off-STP firms (along dimensions such as age of firm, main industrial activity, ownership status, among others) in order to determine the impact of STPs correctly.

²³ In this particular case, the efficiency gains are related to several advantages allocated to the firms' location at the HSIP, for example, enhanced local accessibility to the complete component design and manufacturing supply chain for IT, to R&D-related government support programmes and skilled human resources. In addition, HSIP is characterized by strong links to Silicon Valley-based MNEs due to ties of American Educated engineers returning to Taiwan. It strongly enables local firms' access to advanced international technologies and know-how (Yang et al., 2009; Saxenian, 2001).

localized knowledge spillovers between firms and academia, which are intermediated by STPs. The studies mainly observed informal and human resource linkages, i.e. rather low-level modes of interaction, between co-located firms and research institutions. Formal knowledge relations, however, were only of minor significance. As an illustration, also Lindelöf and Löfsten (2004) have shown that resident firms of Swedish STPs strongly take advantage of informal contacts, as well as the access to scientific equipment and university graduates of universities in vicinity in particular. Industry-academia R&D projects were also implemented, but to a significantly lower degree. Overall, these findings support the notion that spatial proximity is important to enable knowledge spillovers between industry and academia in particular due to the implicit and non-codified nature of knowledge (Jaffe, 1989; Fritsch & Franke, 2004).

On the other hand, many other studies (e.g. Monck et al., 1988; Westhead, 1997; Fukugawa, 2010) have only identified weak interaction between co-located firms and universities in STPs. Consequently, many match-pair analyses have not revealed significant differences between on-park and off-park firms' knowledge linkages to academia in terms of informal interaction or formal cooperation. For example, Westhead and Storey (1994) have stressed that on-parks firms even showed similarly weak levels of information about possible areas of cooperation and potentially available resources of co-located academia.²⁴

In sum, the positive impact of STPs often is primarily associated with positive externalities strengthening the regional economy, improving businesses' performances and stimulating predominantly informal and talent-based industry-academia interaction (Anttiroiko, 2004; Thune, 2009). Nonetheless, the diverse research findings show that the effectiveness of STPs is not guaranteed per se. It varies instead from example to example. Many science parks are considered as successful in fulfilling their goals as anticipated, while many others have failed (Appold, 2004).²⁵ In the academic discussion, it has become clear that STPs do not generate positive effects automatically, and especially not in the short term (Anttiroiko, 2004). More specifically, the development of knowledge relations leading to interactive learning processes in STPs is an incremental and long-lasting process, one that is depend-

²⁴ The empirical divergence is well illustrated in an empirical study of the Sophia-Antipolis technopole. Tel Wal (2008) has provided evidence for localized industry-academia learning processes in the STP's IT cluster, whereas equivalent knowledge interaction could not be detected for the STP's life sciences cluster.

²⁵ Interestingly, findings from STPs in weak and less advanced economies and lagging innovation systems, for example, less developed regions in Italy and Spain, tend to portray a rather positive assessment (e.g. Colombo & Delmastro, 2002; Albahari et al., 2013). In contrast, diverging and more heterogeneous results have been presented for science parks in the UK, Sweden and the USA (Squicciarini, 2008).

ent on a large variety of framework conditions and influential effects.²⁶ Also, time is critical for the development of knowledge interaction between co-located firms and research institutions in STPs (Ter Wal, 2008; Longhi, 1999). In other cases, it is simply unclear whether STP resident firms only look for something different in their business location or locate in STPs due to anticipated economic, technological and knowledge-related externalities (Westhead & Storey, 1994).

2.1.4 Challenges for STPs as designated knowledge-creating and coordinating nodes in the globalizing learning economy

As I have shown in the previous sub-chapter, many empirical studies have stressed that STPs do not sufficiently fulfil their evolutionary grown function as active interfaces that assist resident organizations from industry and academia in expanding their knowledge relations (Siegel et al., 2003b). Some scholars even have pointed with some degree of disappointment and inconsistency to the objectives set by STP promoters and STPs' actual impact on firms' and regions' innovativeness (Hommen et al., 2006). Thus, two challenges for the concept of STPs can be identified in this respect.

Firstly, recent research in fact questions a critical underlying mechanism of the STP concept by arguing that geographical proximity is neither a necessary nor a sufficient condition for knowledge interaction and interactive learning (Boschma, 2005). Also empirical studies of STPs, such as by Vedovello (1997), have indicated that spatial proximity is less important for localized industry-academia interaction than other criteria, namely academic expertise and technical ability, among others.

Secondly, the literature highlights specific measures for improvement in order that STPs adapt substantially to their anticipated role towards active knowledge-creating and coordinating nodes by facilitating and steering direct and indirect knowledge flows between resident organizations and local, but also non-local knowledge sources (Hansson, 2007). In this respect, Westhead & Story (1994) have underlined on-park firms' demand for enhanced efforts by resident universities and research institutions to showcase ('sell') and communicate the services, know-how and resources available to businesses more trans-

²⁶ In addition, a favourable geographical location, a private STP management organization, the entrepreneurial and visionary leadership of certain persons in the STP management, as well as a specific technology focus have been identified as general success criteria of STPs (Link & Scott, 2003b; Sandelin, 2004; Link & Scott, 2007).

parently has been underlined. Distinct entry and low-barrier services, which tackle firms' routine problems may offer trust-building starting points to develop more strategic forms of cooperation at a later point in time (Izushi, 2003). Moreover, basic research, which is prevalent at many on-park universities, is often too theoretical and not related to market needs. Consequently, scientific institutions have to adapt their research activities to cater more strongly to resident firms' demands for market-oriented technological development (Lindelöf & Löfsten, 2003). Responding to the dynamic and more complex innovation model valid in today's knowledge-based economy, Quintas et al. (1992) have argued that STPs must reflect the complete technology development chain from basic research and applied research to development and production, and, finally, to design and marketing.

In addition, several scholars have emphasized that STPs themselves need to strengthen their managerial functions and specialized organizational efforts to initiate and coordinate local and non-local knowledge networks. Specifically installed organizational structures, such as gatekeepers, who retain and develop many contacts to knowledge sources inside and outside of STPs, may enable and promote stronger local and non-local industry-academia knowledge relations (Fukugawa, 2006; Hansson, 2007). Individual empirical studies have already documented positive effects of specific knowledge-creating and coordinating support instruments installed at STPs (e.g. Lazaric, 2008; Fukugawa, 2010).²⁷

As a result of the two challenges underlined, this thesis aims to examine the character and geography, as well as the underlying criteria of STP resident firms' knowledge relations to academia. Regarding the latter aspect, the influence of enhanced organizational efforts of STPs in terms of specific knowledge management instruments is analysed. The gained enhanced understanding aims to contribute to the formulation of policy recommendations strengthening STPs' capabilities as active knowledge-creating and coordinating institutions in the globalizing knowledge-based economy.

2.2 The proximity framework

Knowledge relations and the need for external knowledge are commonly identified as necessary criteria for businesses' and other knowledge organizations' innovativeness and, thus, competitiveness in the knowledge-based economy (Broekel & Boschma, 2012).

²⁷ Additional studies of specific knowledge management instruments applied in local and regional innovation systems are discussed in Chapter 2.3.3.

When persons or organizations initiate and realize interactive relations, opportunity costs are created. Thus, other structural, individual drivers or proximities must be at work that can reduce these costs (Balland, 2012). Proximity refers to “being close to something measured on a certain dimension” (Knoben & Oerlemans, 2006: 71-72). Proximity and distance describe the particular scale of the relationship between actors, while both are dynamic and can gradually increase or decrease. No relationship is associated with the extreme cases; extreme proximity equals identity, while extreme distance equals not knowing the other at all (Stein, 2014).

In the recent academic literature, the consensus is that geographical proximity is neither a sufficient criteria nor a necessary pre-condition for knowledge interaction and, in turn, learning and innovation (e.g. Boschma, 2005; Torre & Rallet, 2005; Gallié, 2009). As Capello (2009) has stated “the idea that pure geographic proximity influences synergies and exchange of knowledge among actors is too simplistic, because it is based solely on the higher probability of contacts in a reduced space” (Capello, 2009: 155).²⁸ At the same time, knowledge interaction over distance has also gained increasing significance, thus illustrating that “knowledge sourcing is a multi-scalar process” (Tödtling & Trippl, 2015: 2).²⁹ Consequently, other mechanisms and dimensions of proximity, which put co-located and also geographically distant actors in relation to each other and explain how knowledge relations are formed, knowledge is shared and interactive learning is enabled, have to be studied in greater detail (Boschma, 2005; Knoben & Oerlemans, 2006).

Already the example of Silicon Valley illustrates the relevance of multi-dimensional proximity, reflected in co-located actors’ shared technology backgrounds, entrepreneurial behaviours and organizational norms that lead to an enhanced local innovation climate and level of knowledge diffusion (Knoben & Oerlemans, 2006).³⁰ Also, various territorial innovation approaches, such as the innovative milieu and Porter’s cluster, point to the important

²⁸ Also Moodysson (2008) has found that knowledge interaction varying from informal knowledge spillovers to formal cooperation rarely is the result of unintended personal interaction, but predominantly is based on rationally planned actions.

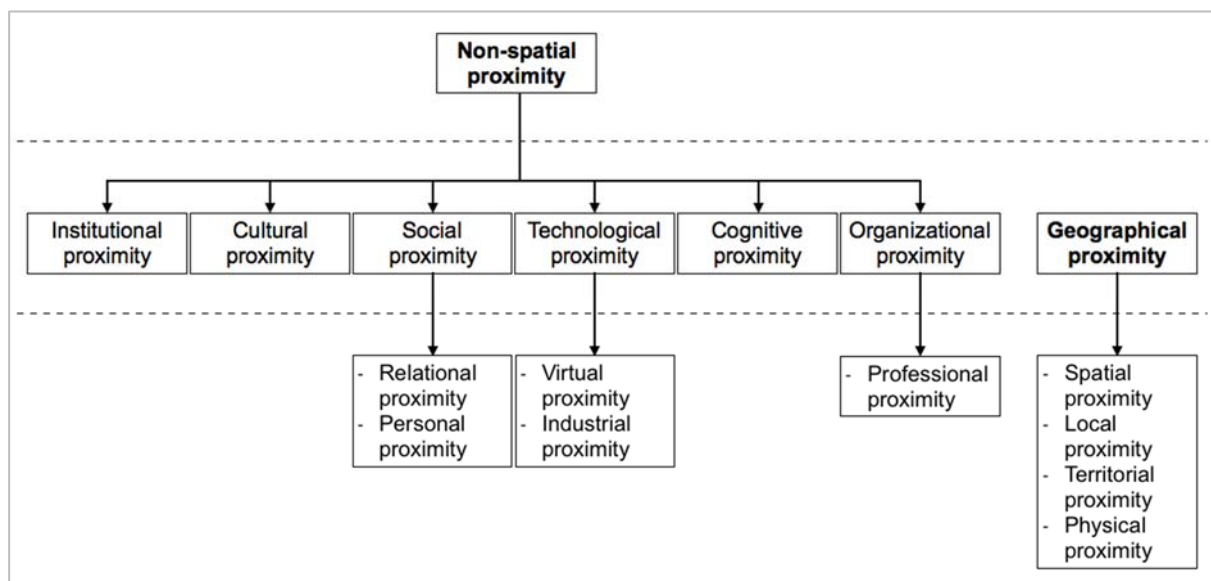
²⁹ In addition to diverse geographical scales of knowledge sources, Grillitsch and Trippl (2014) have stressed the importance of several types of knowledge channels through which knowledge is exchanged. Here, it is distinguished in market links, formal networks, informal networks and spillovers.

³⁰ Giuliani (2007) has highlighted that market relations, socio-institutional thickness, collective identity, as well as informal and formal institutions glue localized knowledge networks in high-technology hubs. Furthermore, such networks also embed intra-cluster and extra-cluster economic and non-economic relations to enable the diffusion of internal and external knowledge. In other words, “it’s not co-location that matters anymore, but belonging to a network” (Gallié, 2009: 39).

role of market relations, socio-institutional thickness and collective identity in the emergence of localized learning (Capello, 1999; Fu et al., 2011).³¹

The French school of proximity dynamics (e.g. Rallet & Torre, 1999; Gallaud & Torre, 2005; Torre & Rallet, 2005) has introduced and continuously pushed the evolution of the proximity framework, while it was further popularized by Boschma (2005), among others. The proximity framework highlights the complex interplay of multi-faceted proximity and distance in knowledge relations and interactive learning. Very broadly, it is distinguished in spatial and non-spatial dimensions of proximity (see Figure 4).

Figure 4: **Composition of non-spatial and spatial dimensions of proximity**



Source: Knoblen & Oerlemans (2006, p. 74)

Overall, the academic discussion stresses the importance of five specific forms of proximity in particular (e.g. Boschma, 2005):

- Geographical proximity (distance of physical space),
- Social proximity (social connectedness),
- Cognitive proximity (similarity of used concepts and mental models, for example, sharing of the same knowledge base),
- Organizational proximity (membership to organizational entities or sub-units, or affiliation across organizational boundaries),

³¹ Mattes (2012) has argued that especially in the concept of the innovative milieu institutional proximity often is mistakenly defined as geographical proximity. Thus, a clear distinction is necessary between geographical proximity (co-location) and institutional proximity (similarity of laws, norms and values).

- Institutional proximity (similarity of systems, rules, norms, incentives, ethical practices, institutions etc., for example, operating in the same country, or operating in the same social subsystem like, for example, within science, industry or government).

Although other alternative approaches have been developed, these five dimensions of proximity, as highlighted by Boschma (2005), among others, are predominantly perceived as the most important forms of similarity in the analysis of knowledge interaction and, in turn, interactive learning processes.³² Therefore, this thesis follows in line with Boschma (2005) and employs geographical, social, cognitive, organizational and institutional proximity as the main analytical framework regarding the development and realization of knowledge relations of STP resident businesses to academia. Their distinct characteristics and interplay are elaborated upon in the following sub-chapters.

2.2.1 Geographical proximity

Geographical proximity is defined as physical or spatial distance between economic actors (in absolute or relative terms). The scale of geographical proximity relates either to the distance between two interacting actors (dyadic level) or the concentration of actors in a geographical unit (agglomerations). Geographical proximity is not a static status, as it changes whenever actors move in space (Knoben & Oerlemans, 2006).

In economic geography, the relation between geographical proximity and innovation is widely discussed. Thereafter, physical co-location provides increasing opportunities for intended or unintended personal interaction, which eventually leads to the exchange of information and knowledge based on enhanced mutual trust and commitment. Face-to-face interaction is particularly important when knowledge is tacit, sticky and complex. Also, the exchange and absorption of codified knowledge is realized more easily, as its implementation often requires tacit knowledge and personal interaction (Gertler, 1995). In addition, spatial proximity not only reduces transaction costs and eases the coordination of intended knowledge sharing, but also creates enhanced opportunities for unintended knowledge spillovers due to the constant and informal stream of information, coined as local buzz by

³² Alternatively, Knoben and Oerlemans (2006) have underlined an integrated approach, which combines the different dimensions of proximity into the three main categories geographical, technological and organizational proximity. Accordingly, organizational proximity captures the assumed rationales of shared routines, norms, values and cultures that are originally highlighted by social, institutional and organizational proximity. This integrated approach especially aims to reduce the conceptual ambiguity between the different types (Knoben & Oerlemans, 2006). Other scholars (e.g. Ibert & Müller, 2015) have also stressed the relevance of cultural, network, and hierarchical proximity, as well as proximity of interest, among others.

Bathelt et al. (2004). However, the literature also highlights that too much geographical proximity and reliance on exclusively local knowledge sources may lead to spatial lock-in and, thus, result in firms' reduced innovativeness (Broekel & Boschma, 2012).

Maskell et al. (2006) distinguish three dimensions of geographical proximity – vertical, horizontal and social. Interactive learning in localized vertically-integrated relationships define the vertical dimension, while the horizontal dimension underscores learning by comparing and observing co-located competitors. Finally, learning processes propelled by unintentional knowledge spillovers and informal interaction define the social dimension of geographical proximity. Temporary geographical proximity adds another component to this type of proximity and its relevance to knowledge relations (Maskell et al., 2006). It implies that permanent co-location is not necessary to build and to take advantage of interactive relations. Instead, temporary co-presence in terms of short visits and joint meetings in conjunction with personal interaction are sufficient enough to develop other forms of proximity, especially social, cognitive and organizational proximity, that can enable effective communication over distance (Bathelt & Henn, 2014).³³ In particular technological advancements in transportation and communication have modified the perception of geographical distance significantly and have contributed to this notion. As a result, the need for geographical co-location for knowledge exchange and diffusion has become more temporary, which is realized through increased mobility and face-to-face interaction now and then (Torre, 2008). In this respect, specific industry and community gatherings such as conferences and trade shows are considered as critical platforms for local and non-local knowledge relations and, thus, are referred to as temporary clusters (Maskell et al., 2006) and temporary trans-local knowledge nodes (Bathelt & Zakrzewski, 2007). As a result, temporary geographical proximity is considered to compensate spatial distance and substitute the need for permanent geographical proximity (Kujath, 2008).

Yet, research findings on the relevance of geographical proximity on learning and innovation activities are two-sided. On the one hand, research has confirmed the importance of co-location of firms and universities for knowledge externalities, especially concerning informal knowledge linkages (Jaffe et al., 1993; Audretsch & Feldman, 1996). Geographical proximity in temporary or permanent settings also remains important to enable the detection of new relevant knowledge, and to facilitate knowledge interaction and exchange (Kujath, 2008).

³³ Bathelt and Henn (2014) have stressed three categories of transfers of knowledge over distance that are built upon temporary spatial proximity and face-to-face interaction, respectively; 1) international community gatherings, 2) international business travel, and 3) transnational network relations.

On the other hand, it has been shown that the exchange of tacit knowledge and, in turn, interactive learning is not spatially delimited. In formalized settings of cooperation, the dependence on unintended encounters due to co-location is weak, given that face-to-face interaction can be organized intentionally, for example, through increased mobility or use of ICT (Rallet & Torre, 2009; Bathelt & Henn, 2014). As a consequence, a large number of empirical studies (e.g. Amin & Cohendet, 1999; Hewitt-Dundas, 2013; Tödtling & Trippl, 2015) have emphasized the multiplicity of knowledge relations, i.e. the coexistence of local and non-local knowledge relations. Bathelt et al. (2004) have expressed this finding in the term local buzz and global pipelines.³⁴

Furthermore, research findings also indicate that the value of geographical proximity for knowledge interaction depends on the stage of cooperation and type of knowledge. For the former, geographical proximity is particularly critical in specific phases of collaborative innovation activities, for instance, when a research project starts. At this stage, highly complex and critical tacit knowledge is typically shared, and often knowledge bases between partner differ greatly, which requires intense and repetitive face-to-face interaction. In other phases of cooperation, such as the commercialization stage, less complex and divergent knowledge is shared, which does not require permanent co-location (Knoben & Oerlemans, 2006; Menzel, 2015). For the latter, firms depending on analytical knowledge tend to be less sensitive to co-location and show patterns of more dispersed interactive relationships. In contrast, companies operating in synthetic knowledge show a higher importance of geographical proximity towards collaborative partners.³⁵ Due to the strong need to relate to place-specific socio-cultural conditions, firms relying on symbolic and cultural knowledge are less involved in non-local knowledge relations (Martin & Moodysson, 2013; Ibert & Hautala, 2015).

In sum, recent research underlines that geographical proximity alone cannot explain knowledge interaction and in particular not the increasing value of non-local knowledge sources and knowledge relations over distance. As a consequence, non-spatial natures of proximity are understood to work independently from geographical proximity and are perceived as more fundamental for knowledge interaction and interactive learning.

³⁴ With the term local buzz, global pipelines, Bathelt et al. (2004) have distinguished between “on the one hand, the learning processes taking place among actors embedded in a community by just being there - dubbed buzz - and, on the other hand, the knowledge attained by investing in building channels of communication – called pipelines – to selected providers located outside the local milieu” (Bathelt et al., 2004: 31). Consequently, global pipelines refer to extra-local interaction in general, for example, on the regional, national and/or international scale.

³⁵ Mansfield (1995) has stressed the important role of spatial proximity for business-to-science interaction in applied research.

2.2.2 Social proximity

Social proximity originates from the concept of embeddedness (Granovetter, 1985), which stresses that most economic linkages are “closely embedded in networks of inter-personal relations” (Granovetter, 1985: 504). In other words, social relations affect economic outcomes. Furthermore, the embeddedness literature has emphasized that the level of social embeddedness positively influences the firm’s likelihood to benefit from interactive learning and innovation processes.³⁶ Two types of embeddedness affecting economic outcomes have been identified: dyadic (i.e. pairwise relationships), and structural (i.e. groups of firms or overall network of relationships) (Granovetter, 1992; Boschma, 2005). Still, a company’s embeddedness is often affected by the embeddedness of individuals (e.g. firm owners, managers and employees) and the firm’s embeddedness as a collective (Oinas, 1997).

Social proximity refers to socially embedded links between individuals at the micro-level, i.e. intertwined social networks of individuals of multiple organizations.³⁷ Socially embedded relations are characterized by trust and reputation based on friendship, family ties, as well as shared personal or work experiences and repeated contacts, for example, through cooperation in the past (Boschma, 2005).³⁸ Social proximity and individual’s embeddedness in a social network, respectively, determine the actor’s ability to access tacit and, sometimes even more or less, confidential knowledge, and, in turn, the likelihood to engage in interactive learning (Breschi & Lissoni, 2003).³⁹ Thus, the main argument behind social proximity is that trust-based social relations enable the exchange of tacit knowledge, which is considered fundamental for innovation. Shared trust enables a more open attitude towards sharing of knowledge between actors, instead of rational and calculated communication. Furthermore, social proximity is usually related to committed and reliable relationships as opposed to pure market and cost-minimizing relationships that may dissolve as soon as problems occur. Therefore, social connectedness also decreases

³⁶ Lundvall (2006) has referred to the importance of know-who in terms of social settings as a specific category within the concept of knowledge. In general, four categories of economically relevant knowledge are differentiated: know-what referring to knowledge about facts, know-why referring to scientific knowledge, know-who referring to specific social relations and networking, as well as know-how referring to skills.

³⁷ More macro-level similarities between actors, for example, shared ethnic and religious values, are incorporated within the concept of institutional proximity (Boschma 2005).

³⁸ Huber (2012) has described three dimensions of social proximity: 1) “knowing each other”, 2) “emotional closeness” and 3) “feeling of personal obligation” (Huber, 2012: 4).

³⁹ For example, Bercovitz and Feldman (2011) have found that prior social ties in collaborative teams increases the team’s innovation performance.

the risk of opportunistic behaviour (Boschma, 2005). Moreover, social proximity also refers to the mediation of trust and trustworthiness between unrelated actors by trusted individuals or organizations (see Box 2). For example, employees, who were co-workers in the past, can connect unrelated firms. Hence, social proximity also is an important criteria for boundary-spanners and intermediaries (Mattes, 2012; Menzel, 2015).

Box 2: **Trust**

Almost all concepts related to knowledge exchange include the notion of trust. Trust appears to be a central prerequisite of knowledge interaction and learning. It affects how and what knowledge is exchanged (Lane et al., 2001; Cooke, 2002). Trust is in particular important in respect to risks of freeriding, opportunistic behaviour and confidentiality. Regarding knowledge exchange, economic actors usually prefer trust-based relationships over newly formed or anonymous ties (Broekel & Boschma, 2012).

Trust combines several dimensions. The confidence in a partner's capabilities and motivation to meet his commitment and obligations refers to the cognitive dimension of trust (Menzel, 2015). So-called intentional trust refers to the belief and attitudes towards the partner's honest motivations, goals, commitments and fair actions, i.e. "that things will not go wrong" (Nooteboom, 2002: 192).⁴⁰ Trust is a feature of existing personal relationships, but it does not explain the creation of new ties, which are important to access new external knowledge. In this case, generally accepted institutions, norms and structures can help to reduce uncertainty, increase the controllability of first joint activities, as well as define realistic expectations and predict partners' behaviours. Also, trust is an evolutionary process, as the its creation requires time and repeated personal interaction. For example, shared experiences increase trust (Dettmann & Brenner, 2010). Furthermore, structural embeddedness on the network level creates trust and reputation. Actors, who are trusted by many other network members, may benefit from networked reputation. Thus, in business networks, it is possible to transfer trustworthiness between actors with no prior relationship. Such trust is typically higher in dense than in loose networks. In contrast, outsiders or loosely linked firms are more likely to suffer a lack of trust and reputation (Glückler & Armbruster, 2003; Menzel, 2015).

Similar to the notion of social proximity and embeddedness, the concept of social capital (Coleman, 1988) also stresses the relevance of personal networks and related resources for the stimulation of cooperative behaviour, knowledge interaction and interactive learning.

⁴⁰ Glückler (2005) has referred to the two types of trust as competence trust and goodwill trust.

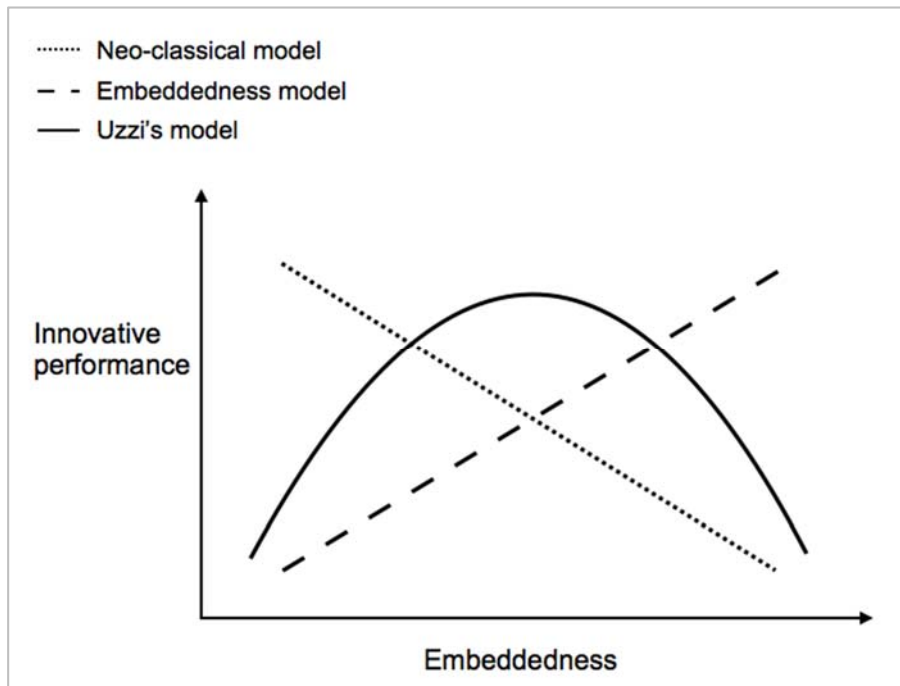
Social capital refers to potentially available assets, which are embedded in the actor's total set of social relations and networks. The collectively owned capital is predominantly related to feelings of gratitude and loyalty or even guaranteed rights associated with the network membership.⁴¹ A firm's ability to create and exploit social capital is found to be an important determinant for its innovativeness. Also, enhanced social capital affects regional economic development positively due to enhanced knowledge and innovation externalities (Nahapiet & Ghoshal, 1998; Huber, 2009).⁴²

However, too much social coherence may limit the learning capability of organizations. Referred to as social lock-in, networks lacking permeability and openness for new actors, information and knowledge may be disadvantageous to firms' innovative capacity. Also, economic relations based on friendship and kinship may lead to irrational decisions and underestimating opportunism. This may result in negative effects on a firm's innovative performance, especially in markets that are characterized by high degrees of uncertainty due to regularly changing technologies and framework conditions, and where opportunistic behaviour is common. As a result, the relationship between social proximity and firms' innovative performance is characterized by an inverted U-shape (see Figure 5).

⁴¹ Three dimensions of social capital are identified; 1) the structural dimension (network ties and network configuration), 2) the relational dimension (trust, norms and obligations) and 3) the cognitive dimension (shared codes, languages and interpretations) (Nahapiet & Ghoshal, 1998).

⁴² In contrast, the concept of network capital underlines the rational perspective of a homo oeconomicus. While social capital is formed in social networks, network capital is created and developed through calculative networks, which are developed and maintained to exploit assets and resources within inter-firm networks based on economic expectations (Huggins, 2010).

Figure 5: **Relationship between firm's embeddedness and innovative performance (inverted U-shape)**



Source: Boschma (2005, p. 67)

Thereafter, the positive relationship between social embeddedness and innovation holds up to a certain threshold, after which effects on interactive learning may become negative due to social lock-in, irrational preferences and underestimated risks of opportunistic behaviour (Uzzi, 1997; Boschma, 2005). Boschma and Frenken (2010) have coined this paradoxical situation the proximity paradox.⁴³

On the whole, social proximity in conjunction with trust is a critical criteria for knowledge interaction to take place. Socially embedded relations and shared trust between actors strongly contribute to a more open attitude towards the exchange of tacit and confidential knowledge, which is fundamental for learning and innovation.

⁴³ The term proximity paradox refers to the paradoxical situation that a certain degree of proximity is considered as prerequisite for the formation of knowledge relations between actors, while too much proximity does not necessarily lead to actors' enhanced innovation performances, but even harm learning (Boschma & Frenken, 2010). In regard to embeddedness in particular, Uzzi (1997) has coined this situation the paradox of embeddedness.

Box 3: **Strong and weak ties**

Strong and weak ties refer to the degree actors are linked, i.e. whether they are either loosely coupled or tightly connected. This concept in social network theory, developed by Granovetter (1973), argues that strong ties formed within densely connected sub-networks (for example, close friends and departments within an organization) are critical for continuous knowledge exchange, while weak ties (e.g. acquaintances) connecting diverse sub-networks are important for accessing heterogeneous knowledge. Thus, both kinds of ties are important for learning (Granovetter, 1973).

In the context of knowledge relations and networks, strong ties encourage trustful, reliable and long-term cooperation between similar actors also in times of uncertainty and environmental changes. Furthermore, they are more suited for transferring highly complex and tacit knowledge (Granovetter, 1973; Nooteboom, 2000a). Examining the strength of ties coupled with network density, McFadyen et al. (2009) have found that strong ties in combination with direct exchange contacts, who have few direct links to each other, show the best results regarding knowledge creation. Also, strong ties seem to be critical to enforce radical changes in organizations affecting the existing status quo and power constellations. Here, trust in the responsible change drivers is critical (Krackhardt, 1992).

In contrast, weak ties are found to be more likely to span boundaries between different sub-networks, thus facilitating the diffusion of diverse, but complementary knowledge. This sets enhanced potential for novel combinations of knowledge and, consequently, innovation. Weak ties, however, appear less effective for the transfer of tacit and complex knowledge (Granovetter, 1983; Hansen, 1999; Nooteboom, 2000a). Also, by connecting diverse knowledge areas in a network or unrelated sub-networks, weak links are critical for the cohesion of a network overall (Glückler, 2007).⁴⁴

2.2.3 Cognitive proximity

People's mental models and knowledge bases differ as they "see, perceive, interpret and evaluate the world differently" (Nooteboom, 2000b: 71). The concept of cognitive proximity builds upon shared mental models and areas of knowledge, as well as sufficient absorptive

⁴⁴ In regard to weak ties, the gatekeeper literature emphasizes the importance of individuals, who take over an important role in connecting otherwise very loosely tied or even disconnected parts of knowledge networks. Also, they link their group or organization to the external environment (e.g. Tushman & Katz, 1980; Giuliani, 2011; Graf, 2011; Kauffeld-Monz & Fritsch, 2013).

capacity as essential requirements for effective communication and, in turn, successful knowledge interaction and learning.⁴⁵ It relates to closeness of cognitive repertoires and overlap of knowledge bases, respectively, on multiple levels; the inter-personal and the inter-organizational level (Nooteboom, 2000b; Thune, 2009).

For successful knowledge interaction and interactive learning, the knowledge bases and competencies of actors should be close enough in order to detect, understand, absorb and exploit the new knowledge successfully (Boschma, 2005).⁴⁶ Cohen and Levinthal (1990) have underlined that “learning is cumulative, and learning performance is greatest when the object of learning is related to what is already known” (Cohen & Levinthal, 1990: 131). If the receiver’s knowledge base and absorptive capacity, respectively, are not sufficient, search and assimilation costs for the required new knowledge will be too high.⁴⁷ Thus, a minimum level of relevant pre-existing knowledge is required in order to deal with the existing knowledge gap successfully (Boschma, 2005). Consequently, firms often seek to build interactive ties to actors with similar references and knowledge bases, for example, in communities of practice (Nooteboom, 2000a; Petruzzelli et al., 2007).⁴⁸

Box 4: **Technological proximity**

Technological proximity is related to cognitive proximity and refers to the similarities between firms’ technological and scientific knowledge. Furthermore, it concerns to what extent companies resemble in “what they produce and/or how they produce it” (Thune, 2009: 9). Knobon and Oerlemans (2006) have distinguished that “cognitive proximity is a much broader concept that refers to the extent to which actors can communicate efficiently, whereas technological proximity refers to the extent to which actors can actually learn from

⁴⁵ Examples of potentially shared or related knowledge bases between actors include factual knowledge, organizational culture, language, theories and experiences (Thune, 2009).

⁴⁶ Furthermore, Capello (2009) has measured cognitive proximity in terms of openness to cooperation and new opportunities, as well as needs of market interactions.

⁴⁷ Absorptive capacity refers to an actor’s ability and capability to identify, absorb, adapt and exploit externally produced and heterogeneous knowledge (Cohen & Levinthal, 1989). It is influenced by actor’s ability and efforts, referred to as inventive capacity, for example, in terms of internal R&D activities, to build prior knowledge bases and expertise inside the organization (Lichtenthaler, 2001). Actors with relevant prior knowledge (i.e. technical and market competencies) are more likely to assimilate new complementary external knowledge and exploit it effectively in terms of learning and innovation. To put it differently, what can be learned is affected by what is already known (Cohen & Levinthal, 1990; Revilla et al., 2005).

⁴⁸ The concept of related variety, often underlined in regional growth theory, also stresses the importance of shared and complementary knowledge bases and competences among different actors and industries in a region. It ensures that some degree of cognitive proximity exists among diverse regional economic actors and industries to enable effective communication, learning, and novel knowledge combination. In contrast, unrelated variety refers to economically not related, disconnected sectors and economic actors in a region (Nooteboom, 2000a; Frenken et al., 2007).

each other” (Knoben & Oerlemans, 2006: 78). Similarity in technological knowledge does not point to technologies themselves, but to the knowledge actors possess about them. Thus, learning and anticipation of technological developments increases with augmenting technological proximity (Knoben & Oerlemans, 2006). However, cognitive proximity and technological proximity are predominantly used synonymously in the literature, for example, in defining cognitive proximity as “degree of technological overlap” (Nooteboom et al., 2007: 1017).

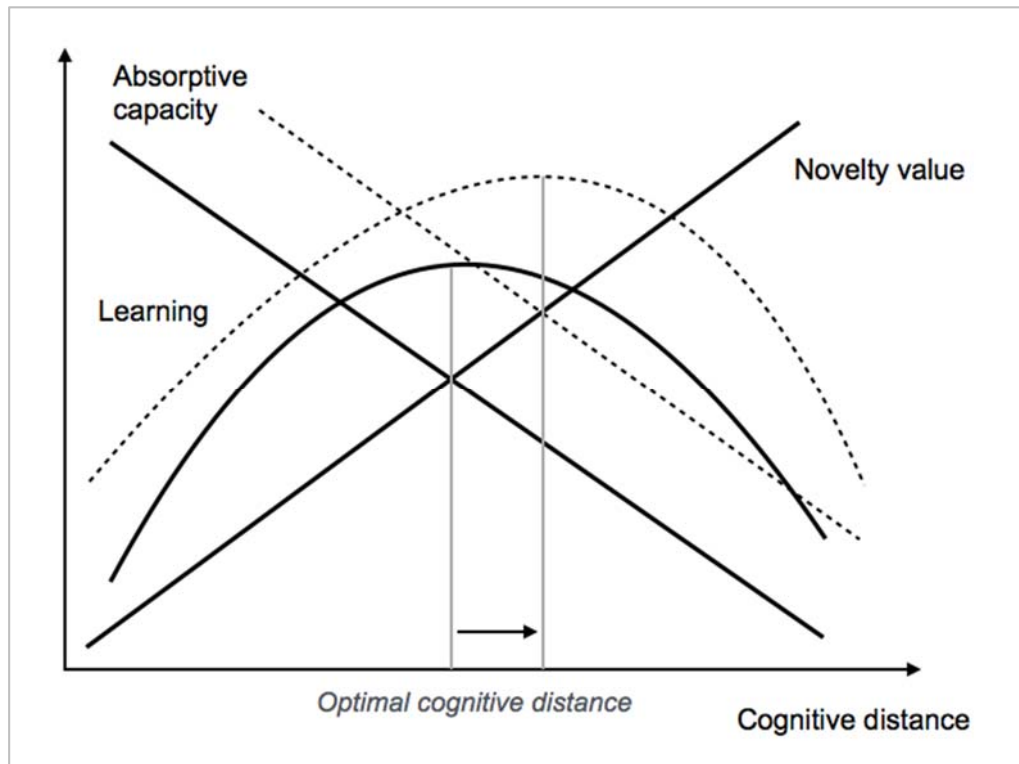
However, too much cognitive proximity may reduce the ability for learning and innovation. Boschma (2005), among others, has identified three reasons why too much technological overlap should be avoided. Firstly, too much compatibility of cognitive repertoires may lead to cognitive lock-in as organizational routines may reduce the awareness and openness for new technology and market opportunities. The creation of new knowledge usually requires different, but complementary knowledge. Secondly, new dissimilar knowledge sources are typically associated with increasing novelty value of knowledge and may provide sources for new knowledge and knowledge re-combinations. Thus, a certain cognitive distance should be maintained to enable interactive learning.⁴⁹ Thirdly, strong cognitive proximity may increase the risk for unintended knowledge spillovers. Cognitively proximate actors, for example, direct competitors, are more capable of absorbing involuntary knowledge spillovers and exploiting them to their benefit (Boschma, 2005; Nooteboom et al., 2007). Nonetheless, too much dissimilarity of knowledge bears the risk of failure in creating an effective common understanding and in the application of external knowledge.⁵⁰ Consequently, a balanced level of shared understanding and knowledge diversity is necessary for learning to occur at all. In other words, cognitive proximity has a positive influence on interactive learning to a certain threshold. Beyond this point, cognitive proximity may reduce the potential for learning. Thus, very proximate as well as very distant actors are unlikely to expect high benefits from cooperation in innovation-related activities. Accordingly, the optimal cognitive distance is reached when the knowledge bases of actors have similar elements that create sufficient comprehension, but also different elements and complementary capabilities that enable new combinations of knowledge and, in turn, interactive learning. As a consequence, the relation between cognitive proximity

⁴⁹ Bercovitz and Feldman (2011) have shown that multi-disciplinary teams composed of researchers of universities, other research institutions and companies are more effective generating successful research commercialization outcomes (e.g. patents, licenses, and royalties) and, thus, stress the importance of knowledge diversity in cases of “truly novel combinations” (Bercovitz & Feldman, 2011: 81).

⁵⁰ Too much cognitive dissimilarity may also reduce the probability of a joint vision and identity, as Grabher (2004) has highlighted in the case of formally composed advertising project teams.

and a firm's innovation performance is also characterized by an inverted U-shaped relationship (see Figure 6), similar to social proximity (Boschma, 2005; Menzel, 2015).⁵¹ As Nooteboom (2000a) has stated “a tradeoff needs to be made between cognitive distance, for the sake of novelty, and cognitive proximity, for the sake of efficient absorption. Information is useless if it is not new, but it is also useless if it is so new that it cannot be understood” (Nooteboom, 2000a: 153).⁵²

Figure 6: **Optimal cognitive distance**



Source: Nooteboom et al. (2007, p. 1018)

Overall, cognitive proximity is regarded as a essential criterion for knowledge interaction and, in fact, the creation of knowledge and learning. A minimum level of shared cognition is a fundamental condition for effective communication and knowledge interaction to occur. Also, it is the only type of proximity that actually provides the potential to create novel ideas

⁵¹ In this respect, Huber (2012) has underlined the distinct interplay of four different sub-types of cognitive proximity; technical language, the way of thinking, know-how and know-what. Accordingly, strong similarity concerning technical knowledge appears important for effective communication, whereas higher levels of dissimilarity of the three other sub-dimensions are more beneficial to learn new things.

⁵² Research shows diverging industry-specific applications of balancing the most effective degree of cognitive proximity. For instance, Grabher (2004) has found that core team composition and interaction in software project ecologies are geared towards reducing cognitive distance and cohesion. In contrast, project organizing in advertising ecologies rather is aimed at promoting cognitive distance and rivalry in order to trigger creativity. Also, the complexity of technological knowledge influences its transferability. Less complex technologies require less mutually shared knowledge, while very complex technologies demand for highly similar knowledge bases (Menzel, 2015).

and technologies based on the sharing of knowledge. Consequently, Boschma (2005), among many other scholars, has underlined that it takes over an prominent role within the proximity framework.

2.2.4 Organizational proximity

Organizational proximity refers to shared relations in terms of the degree of autonomy and exerted control mechanisms, for example, implicit and explicit rules, and coordinating interfaces, in organizational arrangements within or between organizations. In other words, it reflects to which extent actors are affiliated with or belong to the same organizations, related sub-units or across organizational boundaries (i.e. logic of belonging). In a broader definition of organizational proximity, a cognitive dimension in terms of shared knowledge and competencies is added. As a result, two logics are emphasized: the logic of similarity and the logic of belonging (Boschma, 2005; Torre & Rallet, 2005).⁵³ In this thesis, however, the narrow definition is applied as it facilitates the analytical examination of this type of proximity.

The organizational affiliation of actors may take various forms, ranging from informal relationships to formally organized membership clubs (e.g. multi-unit corporate firms), which are characterized by different levels of strategic, economic and/or financial interdependencies. Hence, the different forms also vary in terms of the rate of autonomy of partners and control mechanisms (i.e. governance capacity) over knowledge flows that can be enforced. No organizational proximity is related to independent actors operating in the same markets, while low organizational similarity is associated with informal but shared organizational relations. Organizational proximity increases in governance settings characterized by loosely-tied links, such as industry networks and company joint ventures. A high level of organizational proximity implies strong formal relationships and high hierarchical control, for example, belonging to the same parent organization. Also, hierarchically organized networks, in which members follow specific organizational logics and single control instances decide about all relevant activities, show a high level of organizational proximity. Tightly managed organizational arrangements, for example, multi-unit companies and

⁵³ As outlined earlier, Knoben and Oerlemans (2006) have integrated organizational, institutional, social and cultural proximity into one single dimension of proximity. In addition, cognitive proximity is added to this integrated dimension of organizational proximity. As a result, the broader definition of organizational proximity refers to actors' similarity in organizational structure of governance, culture, performance measurements and language that facilitates the coordination of knowledge transactions without the need to define any codes of conduct and rules beforehand.

strong hierarchical networks not only facilitate knowledge interaction, but also actively coordinate the actual transactions of complex and tacit knowledge (Boschma, 2005).⁵⁴ In general, organizational arrangements may provide solid control mechanisms to coordinate inter-organizational transactions, to ensure ownership of knowledge and returns of previous investments in technology (e.g. intellectual property rights), and, in turn, to allow the economic exploitation of learning processes (e.g. Boschma & Frenken, 2010; Mattes, 2012).

As already mentioned in the discussion about social and cognitive proximity, too much organizational proximity may also have negative effects on learning and innovation performances. Thereafter, very low organizational proximity is accompanied with a lack of control and high risks of opportunistic behaviour. In contrast, an overdependency on strongly tied external knowledge sources may hinder the view for and access to alternative and different sources of knowledge and information (lock-in). Furthermore, too much hierarchy and an associated lack of organizational flexibility are related to low incentives and rewards for proactive innovative behaviour (Boschma, 2005; Broekel & Boschma, 2012). To illustrate, Boschma and Frenken (2010) have pointed to the inability of old industrial regions to renew themselves technologically. Embedded in networks of strongly interwoven industrial clusters and cognitively proximate relations due to long-lasting cooperation in the past, actors are prevented from restructuring organizationally in order to take advantage of new opportunities in times of structural change and crisis.

Thus, loosely tied relations and networks, characterized by organizational proximity at medium-level, are most likely to benefit from both organizational distance and organizational proximity in the context of knowledge interaction and interactive learning. As to the former, loosely tied relationships offer some flexibility and typically come along with the access to diverse, but complementary external knowledge. For the latter, it ensures a stable framework linked to sufficiently strong coordination mechanisms that reduces risks of opportunism and uncertainty (Nooteboom, 2000a; Boschma, 2005).

Overall, organizational proximity is found to be an important driver for knowledge interaction and, thus, interactive learning. As knowledge exchange is characterized by risks of

⁵⁴ For example, Balland (2012) has found that firms in the Global Navigation Satellite System (GNSS) industry rather collaborate with other companies of their corporate group than with organizationally unrelated ones. In this respect, especially strong trust and reduced risks of unintended knowledge spillovers are perceived as the main benefits. Funded cooperation projects even enhance the effect of organizational relatedness. Mattes (2012) has stressed the role of organizational arrangements and control mechanisms in the exchange of analytical knowledge. In this case, organizationally initiated knowledge sharing processes, for example, through permissions of governance structures appear more important than common institutions on the macro-level.

opportunism, organizational arrangements in conjunction with certain control mechanisms reduce uncertainty, thus enabling the open sharing of knowledge.

2.2.5 Institutional proximity

The notion of institutional proximity can be traced back to North (1990), who argued that specific institutional frameworks at the macro and micro level are critical in order to reduce risks of opportunistic behaviour and to ensure effective cooperation in economic relations. In contrast to social and organizational proximity, institutional proximity refers to the degree of similarity concerning the institutional framework (i.e. set of common rules, laws, norms, customs, sanctions and codes of conduct) as enforcement mechanisms at the macro level.⁵⁵ Thus, shared formal institutions (e.g. laws, regulations and rules) and/or informal institutions (e.g. norms, values, habits, background and routines) contribute to the creation of a stable framework as they reduce uncertainty and transaction costs. Both forms of institutions have a positive effect on inter-organizational knowledge relations, especially when tacit and complex knowledge is shared and created (Boschma, 2005; Boschma & Frenken, 2010).⁵⁶

Hence, an environment, in which actors operate in the same framework of formal and informal institutions, such as the commonly accepted regulations regarding the ownership of intellectual property, the same language and shared norms, is considered a critical enabler of knowledge relations. At the same time, however, institutional proximity can also restrain knowledge exchange and learning. On the latter aspect, two institutional extremes are possible. On the one hand, too much institutional proximity may hamper learning and, in turn, innovation due to an unwillingness to try new institutions, which are necessary to develop and implement new ideas and innovations successfully. This kind of institutional rigidity is expressed in a lack of awareness of new sources of ideas and the creation of insurmountable institutional entrance barriers for new knowledge sources. Also, strong institutional players may simply prevent any institutional changes in order to maintain their dominant

⁵⁵ Social and organizational proximity refer to specific institutional arrangements at the micro level. This already points to a strong interrelation between social, organizational and institutional proximity (Boschma, 2005). This interplay, among others, is outlined subsequently.

⁵⁶ In addition, Knoben and Oerlemans (2006) have highlighted that institutional proximity refers to two different levels of analysis; on the one hand, institutional contexts at different territorial scales of nations and regions (e.g. laws, cultural norms, business practices, education and training systems), and on the other hand, enforced norms and routines on the organizational level, which are based on a distinct territorial institutional framework.

position. On the other hand, too weak institutional proximity in terms of ineffectually enforced laws and, thus, high uncertainty is typically harmful to interactive learning and innovation (Boschma, 2005; Boschma & Frenken, 2010; Mattes, 2012). Consequently, the optimal institutional framework for successful knowledge interaction and interactive learning “needs to reflect a kind of balance between institutional stability (reducing uncertainty and opportunism), openness (providing opportunities for newcomers) and flexibility (experimenting with new institutions)” (Boschma, 2005: 68).

Various empirical studies have emphasized institutional dissimilarities for companies and scientific institutions in particular and, thus, for the models of the triple and quadruple helices (Ponds et al., 2007; Balland, 2012).⁵⁷ Thereafter, institutional discrepancies are twofold in this context. Firstly, scientific research is often completely different from industrial technological development.⁵⁸ Secondly, the objectives and underlying incentive structures of industry and academia are conflicting. Whereas scientists aim to add new findings to the existing public knowledge base through publications and other forms of open knowledge diffusion, technological development and R&D activities of companies aim to generate profits through the creation, possession and commercialization of private knowledge (e.g. Ponds et al., 2007; Boschma & Frenken, 2010). For university-firm linkages, Thune (2009) has underlined that institutional closeness in terms of “familiarity with working methods, approaches to problem solving, the understanding of time constraints and the need for control” (Thune, 2009: 13) limits tensions and defines the quality of interaction and collaboration.

In sum, institutional proximity is identified to be an critical criteria for knowledge relations. Commonly shared formal or informal institutions reduce uncertainty and, thus, affect the likelihood of productive knowledge interaction positively.

⁵⁷ Different institutional contexts also are allocated to different industries. Ibert and Müller (2015) have stressed diverging institutional regimes, for example, concerning the handling of intellectual property rights, as well as the role of formal regulations and public funds in innovation processes in legal services and biotechnology-related R&D services.

⁵⁸ There is a different institutional distance of basic and applied research to industry. Applied research is more strongly allocated towards the industry’s needs and demands. Thus, there is a smaller institutional distance between applied research institutions and industry (Ponds et al., 2007; Boschma & Frenken, 2010).

2.2.6 Hierarchy and interplay of the proximity framework

The recent academic discussion of the proximity framework stresses the importance of multiple types of proximity, in particular cognitive, geographical, institutional, organizational and social proximity, in the context of link creation, knowledge interaction and learning (e.g. Boschma, 2005; Menzel, 2015; Cassi & Plunket, 2014). In case of the hierarchy of the specific types of proximity for the creation and realization of knowledge relations, which is developing incrementally in the academic discussion, one tenet is identified, while other aspects still are not clarified unequivocally.

As I have stated at the beginning of this chapter, it implies that physical co-location alone does not directly lead to link creation, knowledge interaction and interactive learning (Boschma, 2005).⁵⁹ Instead, knowledge relations always imply an intention to interact, to share and to acquire information. Thus, it needs other forms of proximity (Mattes, 2012).⁶⁰ Yet, the primary role of permanent and temporary geographical proximity is to facilitate the creation of more critical non-spatial natures of proximity through reduced transaction costs and enhanced opportunities of personal interaction. Consequently, geographical proximity is considered as an auxiliary factor in knowledge relations overall (Boschma, 2005; Balland et al., 2015; Menzel, 2015).⁶¹

Commonly, non-spatial forms of proximity (i.e. cognitive, social, organizational, institutional proximity) are understood as having more value for knowledge relations and interaction than geographical proximity and function mainly independently or at best complementary to geographical proximity (Boschma, 2005; Mattes, 2012). Foremost, cognitive proximity takes over an outstanding role among the different natures of proximity. This can be considered as an additional tenet of the proximity discussion. It is an essential prerequisite to provide a sufficient basis of shared understanding and knowledge for the creation of inter-

⁵⁹ Also, imitative learning processes of co-located actors (i.e. learning by observing and comparing) hardly seem possible without certain shared competences in a specific technology or knowledge areas enabling to identify, absorb and process external knowledge. Thus, several scholars have underlined that geographical proximity must be supplemented by at least one other type of proximity (Boschma, 2005; Galli , 2009; Ibert & Hautala, 2015).

⁶⁰ For example, geographical proximity does also not automatically imply social proximity as distinct business networks (e.g. epistemic communities and communities of practice) are very selective and not pervasive, i.e. never include all co-located actors (Dahl & Pedersen, 2004).

⁶¹ Despite the higher value of non-spatial proximities for knowledge ties and learning, geographical proximity still is regarded to positively affect the creation of knowledge linkages (Balland et al., 2015).

active links, knowledge interaction and learning (Boschma, 2005; Menzel, 2015).⁶² Importantly, cognitive distance is not static, but can be reduced by frequent interaction (Balland et al., 2015).⁶³ Furthermore, organizational and institutional proximity are perceived as critical enablers of link creation and knowledge interaction. Thereafter, both natures of proximity come into play as strategic, control-related and normative dimensions, respectively, after a sufficient degree of cognitive similarity is in place. Moreover, social proximity in conjunction with trust, for instance, through past cooperation and shared personal experiences, which increase the likelihood for actors to share complex and tacit knowledge openly, is predominantly seen as an enabling criterion or auxiliary factor (Boschma, 2005; Mattes, 2012).

Knowledge relations and networks need to have a particular type of proximity configuration, i.e. the distribution of degrees for at least one type of the different kinds of spatial and non-spatial proximity among tied actors, to be effective (Broekel, 2015). Constellations of the different proximities are neither universal nor fully industry specific. They rather are subject to a constant trade-off between various proximities substituting, compensating and bridging too strong distances in other dimensions, as well as a dynamic process of proximity adaptation (Mattes, 2012).

Especially the former strand of research is of importance for this thesis. Generally, small distances can be compensated more easily than larger distances (Menzel, 2015). A general compensation mechanism suggests that distance in one dimension can be compensated by at least one other type of similarity. Due to its accentuated role, cognitive distance in terms of knowledge gaps cannot be easily substituted (Huber, 2012). Instead of a compensating mechanism, the relation between cognitive proximity and the other types examined of proximity is characterized by a complementary relationship and positive correlation. Thus, by facilitating intense personal interaction, spatial co-location, trust, shared norms and values, as well as certain organizational settings can act as critical enablers or auxiliary factors of enhanced cognitive proximity (Cassi & Plunket, 2015).⁶⁴

⁶² Balland et al. (2015) have stressed that “a fundamental requirement for effective knowledge networking to take place is some minimum level of cognitive proximity” (Balland et al., 2015: 5).

⁶³ Proximity in whatever dimension is dynamic by nature. Generally, interaction reduces distances and, in turn, increases proximity in potentially any dimension (Balland et al., 2015; Menzel, 2015).

⁶⁴ In particular, in the initial stages of collaborative activities, when knowledge between partners differs strongly, geographical proximity facilitates improved comprehension and absorption of highly complex knowledge. The relevance of geographical proximity for knowledge interaction decreases over time as cognitive proximity (along with potentially social, institutional and/or organizational proximity) increases with the maturity and status of the relationship (Broekel, 2015; Dettmann & Brenner, 2010).

Apart from that, Balland et al. (2012) has indicated that geographical, social, institutional and organizational proximity can substitute each other in the formation of knowledge ties, due to their similar roles as either enabling and/or facilitating factors. Firstly, the literature indicates that geographical distance can be compensated by all other proximities examined. Organizational proximity in terms of formal networks, coordinated projects and strategic alliances is considered essential to access and enable the exchange of non-local implicit and explicit knowledge (Knoben & Oerlemans, 2006). Also, social proximity due to prior work experiences and social relationships is considered as a compensatory mechanism mitigating the disadvantages of geographical distance and enabling effective knowledge interaction over distance (Boschma & Frenken, 2010). Moreover, institutional proximity enables successful knowledge interaction over distance. For example, in inter-university cooperation, geographical proximity becomes less important as universities around the world share a similar framework of incentives, objectives and working cultures (Ponds et al., 2007). A strong compatibility of knowledge bases, for example in communities of practice and epistemic communities, also allows meaningful communication and the exchange of complex knowledge despite geographical dispersion.⁶⁵ Finally, knowledge interaction over distance is strongly facilitated by temporary geographical proximity, for example, in terms of industry conferences and trade shows. Thus, co-presence in conjunction with increased mobility is found to substitute the need for permanent geographical proximity (Menzel, 2015).

Secondly, compensatory mechanisms of social and geographical proximity in the case of too much institutional distance are underlined in the literature. In case of a weak legal system linked to only selectively enforced laws (e.g. ownership rights and intellectual property rights) at the macro level, actors may take advantage of trust-based, personal relations at the micro level instead (Boschma, 2005). In addition, territorial innovation approaches suggest that geographical proximity helps to overcome institutional distances in terms of organizational objectives between industry and academia (Balland et al., 2015; Hardeman et al., 2015). However, various empirical studies on industry-academia interaction in STPs have revealed ambiguous findings about the role of physical co-location as substitute for the given institutional dissimilarity, as I have outlined in Chapter 2.1.3.

⁶⁵ Communities of practice are groups of persons in the same practice, who are interested in enhancing individual competencies, communicate regularly and share a common set of resources (Wenger & Snyder, 2000). In contrast, epistemic communities are characterized by their professional certification, interests and semantic discourse, like for example, professional associations (Cooke, 2007).

Thirdly, organizational and institutional proximity are perceived to compensate for the lack of social proximity. In contrast to personal trust and loyalty, the former uses the mechanism of hierarchical forms of governance to build strong collaborative ties. The latter points to interactive relationships and knowledge interaction derived from enforced rules and control mechanisms on the macro level (Boschma, 2005). In reverse effect, social proximity also can substitute for too much institutional and organizational distance, as mentioned earlier. Accordingly, social proximity is also referred to “as a micro-level manifestation of organizational and institutional proximity” (Thune, 2009: 10).

Regarding the dynamic process of proximity adaptation, Broekel (2015) has distinguished three processes: simultaneous co-evolution, long-term evolution and temporal autocorrelation. Thereafter, various positive correlations of specific forms of proximity can be observed. By facilitating personal interaction, geographical proximity correlates positively with social proximity (i.e. co-location enabling the development of personal interaction and building of trust) and cognitive proximity (i.e. co-location facilitating shared understanding). In this respect, cognitive and social proximity are also positively correlated (i.e. increasingly shared cognition based on shared personal experiences). In addition, co-location promotes the development of mutual entrepreneurial behaviours, common norms and values. Moreover, institutional proximity correlates positively with organizational proximity, as a stable institutional framework is the prerequisite for the establishment of organizational arrangements such as joint ventures and strategic alliances (Boschma, 2005; Gertler & Wolfe, 2000). Finally, actors sharing the same institutional framework and organizational focus usually share certain knowledge and competencies. Also, repeated interaction and first interactive experiences result in the development of mutual values, routines and rules (Nooteboom et al., 2007). However, this avenue of research is not a primary focus of this thesis.⁶⁶

As a summary, Table 2 provides an overview of the theoretical implications and empirical findings of the proximity framework in the academic discussion.

⁶⁶ Additional strands of research linked to the proximity framework, which are not subject of analysis in this thesis, focus on the role of specific types of proximity and distance when relationships and networks are created and dissolved (e.g. Balland, 2012), or examine the dynamic interplay of proximity in knowledge relations characterized by different knowledge bases (e.g. Mattes, 2012).

Table 2: Definition, role and trade-offs of the proximity framework

	Key dimension	Function	Compensatory mechanisms	Positive correlation
<i>Cognitive</i>	Knowledge gap	Outstanding prerequisite		
<i>Institutional</i>	Trust (based on common institutions)	Critical enabler	Social proximity	Organizational proximity (institutional reliability to form organizational arrangements), cognitive proximity (repeated interaction)
<i>Organizational</i>	Control	Critical enabler	Social proximity	Social proximity (development of trust), cognitive proximity (repeated interaction)
<i>Social</i>	Trust (based on social relations)	Enabling / auxiliary criterion	Institutional proximity, organizational, proximity	Cognitive proximity (repeated interaction)
<i>Geographical</i>	Distance	Auxiliary factor	Institutional proximity, organizational, proximity, social proximity, cognitive proximity	Social proximity (development of trust), institutional proximity (development of shared norms and values), cognitive proximity (repeated interaction)

Sources: Based on Boschma (2005), Balland et al. (2015), Broekel (2015), among others

2.2.7 Limitations and research needs

The academic discussion of the proximity framework also reveals some limitations and constraints. These are linked to recent research trends and needs for further research.⁶⁷

One main criticism is that the academic discussion is often biased towards proximity, while the relevance of distance regarding learning and innovation is neglected. Yet, recent studies (e.g. Ibert, 2010; Grabher & Ibert, 2014; Ibert & Müller, 2015) have placed more emphasis on the importance of distance for knowledge interaction, the creation of novel ideas and innovation. However, the need for a certain balance of proximity and distance for learning and, in turn, innovation is also reflected in the term proximity paradox and in the inverse U-shaped relation between specific forms of proximity and a firm's innovative performance (see Table 3), underlined by Boschma (2005) and other scholars (e.g. Uzzi, 1997).

As a consequence, an actor's optimal knowledge network (i.e. knowledge linkages with positive net gains of interaction and collaboration) should comprise ties to proximate partners and dissimilar partners at the same time. For example, regarding the optimal social proximity, knowledge networks should comprise a balance of strong ties and weak ties connecting different sub-systems. Moreover, in terms of geographical proximity, a balance between local and non-local relations is underlined (Boschma, 2005; Balland et al., 2015). However, only rare empirical evidence for the proximity paradox is found so far.⁶⁸

⁶⁷ Additional criticism underlines that the dimensions of proximity often suffer a certain extent of conceptual overlap and, thus, can hardly be distengaled, for example, cognitive proximity and technological proximity. As a result, integrated definitions of certain types of proximity have been developed, for example, by Knoblen and Oerlemans (2006). Furthermore, different levels of analysis, namely the dyadic and the network level, need to be distinguished in the academic discussion of the proximity framework (Knoblen & Oerlemans, 2006).

⁶⁸ Broekel and Boschma (2012) have found that social, geographical, cognitive and organizational proximity increase the likelihood for the successful formation of knowledge links and effective knowledge exchange. Yet, the proximity paradox only holds for cognitive and organizational proximity. They do not foster higher performance effects of firms, whereas geographical and social proximity do so.

Table 3: Proximity paradox and optimal levels of proximity for learning

	Key dimension	Too little proximity	Too much proximity	Possible solutions
1. Cognitive	Knowledge gap	Misunderstanding	Lack of sources of novelty	Common knowledge base with diverse but complementary capabilities
2. Organizational	Control	Opportunism	Bureaucracy	Loosely coupled system
3. Social	Trust (based on social relations)	Opportunism	No economic rationale	Mixture of embedded and market relations
4. Institutional	Trust (based on common institutions)	Opportunism	Lock-in and inertia	Institutional checks and balances
5. Geographical	Distance	No spatial externalities	Lack of geographical openness	Mix of local 'buzz' and extra-local linkages

Source: Boschma (2005, p. 71)

Another criticism is that empirical studies of territorial innovation systems in general and STPs in specifically have primarily investigated the specific influence of geographical proximity on localized knowledge relations and knowledge interaction. Though, the role of non-spatial proximity, which is observed to have a more critical and even essential role in the development and realization of local and extra-local knowledge relations, has been predominantly disregarded (Hardeman et al., 2015). Furthermore, more empirical work has to be done to analyse the complexity of the proximity framework overall and in regard to specific constellations of proximity in the large variety of inter-organizational knowledge relations (Boschma, 2005; Broekel & Müller, 2015).⁶⁹

Consequently, in this thesis I aim to examine the relevance and interplay of multi-dimensional proximity influencing the likelihood of successful knowledge link formation and

⁶⁹ Broekel and Müller (2015) have criticized that the proximity framework and related empirical studies help to explain knowledge link formation, as well as the emergence and impact of the average link in inter-organizational knowledge networks in general. However, the wide heterogeneity of inter-organizational links is neglected.

knowledge interaction between industry, represented by technology-oriented STP resident companies, and academia in particular.

2.3 Knowledge management in territorial innovation systems

2.3.1 Definition of knowledge management

Since there is a correlation to the increasing consensus of knowledge as a decisive determinant for firms' competitiveness and innovativeness in the knowledge-based economy, there has been increased interest in specific actions to manage knowledge to a company's benefit. There is a major focus on knowledge management, as a broad concept, in the literature on strategic management and organizational learning. Especially on the organizational scale of firms (e.g. 3M, Hewlett-Packard, Microsoft, Toyota and Xerox) and inter-organizational alliances (e.g. strategic alliances, joint ventures and joint R&D projects), the application and derived positive effects of knowledge management systems and practices have been underlined in the academic discussion (Inkpen & Dinur, 1998; Dyer & Nobeoka, 2000; Revilla et al., 2005; Meier, 2011, among many others). In addition, the concept of knowledge management has been increasingly extended to territorial innovation networks and systems such as knowledge regions, knowledge cities and STPs (e.g. Harmaakorpi & Melkas, 2005; Kujath, 2008; Kujath & Schmidt, 2010).

Knowledge management is defined as the whole life cycle from knowledge creation, processing to leveraging into value in order to increase the organization's efficiency, competitiveness and innovativeness. Accordingly, knowledge management refers to actively installed practices in terms of organizational routines, as well as control and coordination mechanisms that actors use intentionally to govern knowledge processes and to influence knowledge activity outcomes (Quintas et al., 1997; Willke, 1998; Alavi & Leidner, 2001). Knowledge management is considered as a continuous, open-ended process. Firms as learning organizations in today's learning economy have to cope with knowledge environments constantly and quickly changing due to new categories of required knowledge, technologies, management approaches, regulatory issues and customer feedback. As a consequence, firms constantly have to adapt and modify their strategies, their organizational structures, as well as their products and services. Furthermore, new talent contributes new knowledge and, in turn, has new knowledge needs (Davenport,

1997).⁷⁰ By and large, multiple processes of knowledge management can be identified; 1) knowledge identification; 2) internal knowledge creation and external knowledge acquisition, 3) knowledge storage and retrieval, 4) sharing of knowledge internally and externally, and 5) knowledge application (Bhatt, 2001; Alavi & Leidner, 2001; Willke, 2001).⁷¹

The process of knowledge identification focuses on certain instruments to detect suitable knowledge. Also, it comprises capabilities to assess and validate the existing knowledge and to determine what kind of new knowledge is needed to remain competitive and innovative (Durst & Edvardsson, 2012).

Moreover, the process of organizational knowledge creation is linked to internal and external learning. While internal learning competence refers to an organization's ability to generate new knowledge inside the organization (inventive capacity), external learning competence signifies an organization's capability to identify, absorb, adapt and exploit externally produced and heterogeneous knowledge (absorptive capacity).⁷² This also implies the ability to combine and reconfigure new knowledge with current knowledge (Lichtenthaler, 2001; Alegre et al., 2013).⁷³

Furthermore, the process of knowledge storage and retrieval refers to specific practices in order to document and memorize the status quo of organizational knowledge. It primarily

⁷⁰ The Toyota group is one of the most famous case studies of corporate knowledge management systems discussed in the academic literature. Accordingly, a mix of bilateral and multilateral mechanisms was implemented to enhance the transfer of implicit and explicit knowledge between Toyota and its suppliers. On the one hand, voluntary learning teams (so-called PDA groups) were installed to spur the exchange of tacit knowledge in particular among the OEM and its suppliers. On the other hand, the intentionally established Toyota Supplier Association (BAMA) was in charge of the dissemination of explicit and codified knowledge (e.g. reports and analyses) within the entire Toyota group. Dyer and Nobeoka (2000) have highlighted the importance of creating a mutual identity and common rules stressing the role of production-relevant knowledge as a common good of Toyota and its top-tier suppliers. Also, the principle of reciprocity was commonly applied. As a result, initially weak ties evolved to strong links among suppliers themselves, and between the OEM and its suppliers (Dyer & Nobeoka, 2000).

⁷¹ Slight differences exist in the literature concerning the number and labelling of the different processes of knowledge management, but not regarding the underlying concepts overall (Alavi & Leidner, 2001). For instance, Bhatt (2001) has additionally underlined the processes of presentation of knowledge (i.e. making it accessible, which is inherent to knowledge sharing) and knowledge updating.

⁷² The concepts of absorptive and inventive capacity have been briefly discussed in Chapter 2.2.3.

⁷³ The underlying mechanisms of knowledge creation are comprehensively described in the SECI model of Nonaka (1991, 1994). The SECI model stresses four distinct, but highly interrelated modes of knowledge creation; socialization, externalization, combination and internalization. Thereafter, the creation of organizational knowledge is characterized by a complex interactive process of tacit and explicit knowledge, as well as multiple feedback loops on individual, group and organizational scales - the so-called "spiral of knowledge" (Nonaka, 1994: 20). Consequently, newly created knowledge instantly becomes the basis for further knowledge (Nonaka, 1991; Nonaka, 1994). Furthermore, for each process of knowledge creation of the SECI model, one corresponding type of *ba* is identified. In general, *ba* describes different spaces or platforms of interaction: physical (e.g. café), social (e.g. conversation), cultural (e.g. customs), mental (e.g. shared personal experiences and ideas), economic (e.g. trade) or virtual (e.g. web chat rooms and email) (Nonaka & Konno, 1998; Nonaka & Toyama, 2003).

compounds documented and codified knowledge in various forms, for example, written documentation, structured electronic databases, archives, expert systems, as well as documented organizational processes and procedures. Most importantly, it has to ensure that useful knowledge is organized effectively and is easily accessible (Alavi & Leidner, 2001).

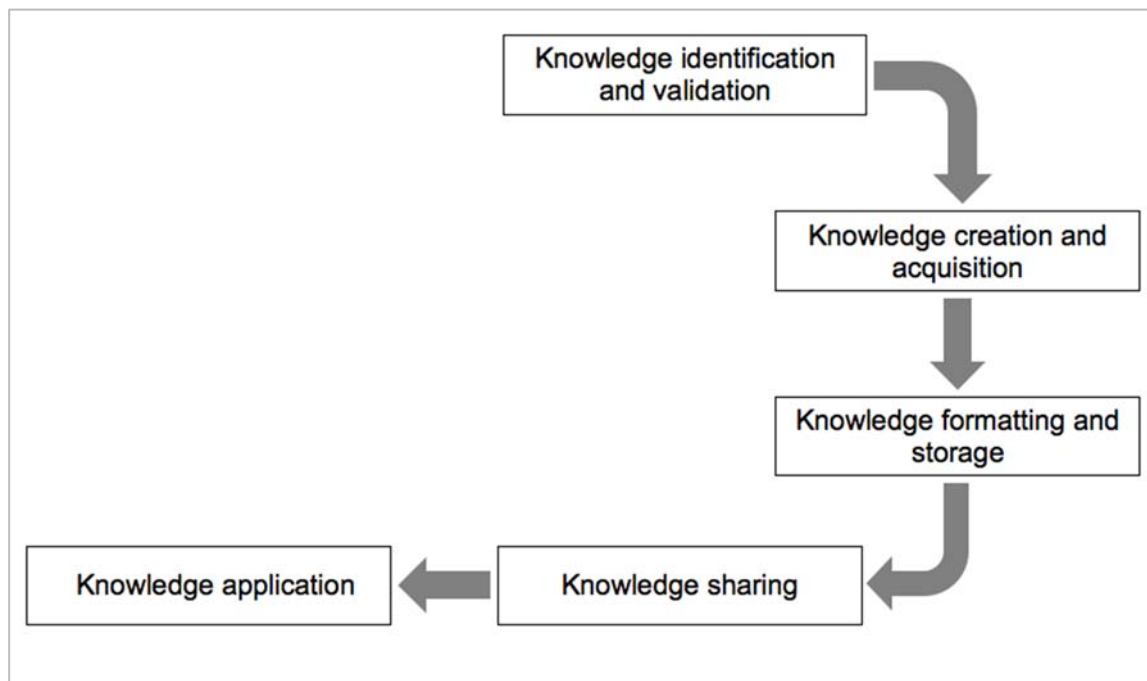
In addition, the process of knowledge sharing includes the dissemination of tacit and explicit knowledge. While explicit knowledge is easy to codify and disseminate, tacit knowledge is more difficult to disseminate and requires personal interaction (Alegre et al., 2013). The sharing and dissemination of knowledge may occur on various levels, for example, between individuals (nodal level), between groups and organizations (dyadic level), and in entire networks (systemic level).⁷⁴ Three formats to facilitate the sharing of knowledge in organizations are differentiated: informal (e.g. informal meetings, email groups, virtual networks, bulletin boards), formal (e.g. multi-unit task forces, training sessions, plant visits) and personal modes (e.g. staff exchange, job transfers, internships and apprenticeships) (Alavi & Leidner, 2001; Gupta & Govindarajan, 2000).

Ultimately, the process of knowledge application emphasizes the integration and exploitation of new knowledge to be absorbed, which represents the actual source for an organization's competitiveness. Knowledge management tools such as directives, organizational routines and specific task teams can support this process (Alavi & Leidner, 2001).⁷⁵ Figure 7 summarizes the mentioned elements of the knowledge management process.

⁷⁴ Gupta and Govindarajan (2000) have allocated five elements to the process of knowledge transfer; 1) perceived value of the potential source's knowledge, 2) willingness of the source to share knowledge, 3) existence and effectiveness of knowledge transmission channels, 4) receiver's willingness to acquire to sender's knowledge, and 5) receiver's absorptive capacity to absorb and apply the new incoming knowledge.

⁷⁵ Directives refer to specific rules, standards, procedures and instructions that are compiled based on the conversion of specialists' tacit knowledge to explicit knowledge for effective communication to non-specialists. Examples are manuals, checklists, policies and standards. Organizational routines are task-specific performance and coordination patterns that allow specialists to apply their tacit knowledge without the necessity to articulate it to others. Examples are take-off routines of an airplane cockpit crew. Finally, specifically formed teams of individuals with specialized knowledge and experiences can enable the effective application of knowledge in conditions of high uncertainty and complexity, when the development of specified directives and organizational routines is not possible (Alavi & Leidner, 2001).

Figure 7: **Processes of knowledge management**



Source: Bhatt (2001, p. 71) (modified by author)

In general, three main categories of knowledge management instruments and practices, respectively, can be distinguished:⁷⁶

- Information management refers to IT and related information systems and software, through which internal knowledge is codified, stored and made accessible to anyone. The literature names various main applications of IT technologies to organizational knowledge management; capturing and dissemination of information (e.g. data mining and intranet), coding and sharing of best practices (e.g. through benchmarking), creation of organizational knowledge directories (e.g. mapping of expertise), virtual communities of practice (e.g. online forums) and communication tools facilitating cooperation and teamwork (Bhatt, 2001; Choo & Alvarenga Neto, 2010).
- People management underlines the important role of people and groups in creating, managing and interpreting very complex, tacit and highly interpretative forms of knowledge. Thus, related practices are centred around talent as knowledge carriers and respond to the importance of social relations and interpersonal trust for organizational knowledge, as tacit and experience-based knowledge is linked to the individuals that developed it and can only be shared, interpreted and newly combined through direct

⁷⁶ The three main categories of knowledge management instruments already point to the importance of organizing specific types of relational proximity such as cognitive, social and organizational proximity in order to overcome certain dissimilarities that exist between individuals and organizations.

face-to-face interaction among persons and groups. Related practices can be specifically designed to either promote the exposure to shared knowledge based on common beliefs and cognition (e.g. communities of practices), or to diverse knowledge reflecting different backgrounds and mental models (Gloet & Terziovski, 2004; Revilla et al., 2005).⁷⁷

- External structures comprise organizational structures that are installed to contribute to knowledge sharing and other kinds of knowledge activities. Examples are collaborative work structures (e.g. project teams, autonomous teams, cross-divisional units, inter-organizational projects), knowledge managers and mediators (e.g. Chief Knowledge Officers), knowledge sharing incentives (e.g. incentive systems and mentoring programmes), as well as specific virtual, physical and temporal spaces dedicated to knowledge creation and sharing (Choo & Alvarenga Neto, 2010).⁷⁸

Overall, organizational or inter-organizational knowledge management systems and practices do not ensure successful knowledge interaction and learning per se. They aim to encourage and facilitate knowledge flows between individuals, groups and organizations and to overcome barriers harming the transfer and exchange of knowledge. The tacitness of knowledge, the lack of absorptive capacity, a low willingness of employees, a weak incentive structure to share knowledge, low quality relationships between actors, as well as a lack of organizational structures such as communities of practice and collective knowledge creation spaces are named as the most fundamental obstacles to knowledge sharing in organizations (Gupta & Govindarajan, 2000; Durst & Edvardsson, 2012). In inter-firm relations, different work cultures and products, as well as exogenous events (e.g. crisis, mergers & acquisitions), among others, are identified as further barriers of inter-organizational knowledge sharing and learning (Revilla et al., 2005).

⁷⁷ Seufert et al. (1999) has highlighted the organizational coordination of people as knowledge carriers and social interaction as important determinant for knowledge transfer and creation in the term knowledge networking. It refers to “a number of people, resources and relationships among them, who are assembled in order to accumulate and use knowledge primarily by means of knowledge creation and transfer processes, for the purpose of creating value” (Seufert et al., 1999: 184).

⁷⁸ Hautala (2011b) has pointed to direct and indirect knowledge management practices and tools in inter-academia collaboration. Direct knowledge management activities comprise group leaders guiding their projects and project team members. In contrast, the setting up and cultivation of specific working environments (e.g. collaborative spaces), structures (e.g. knowledge managers) and organizational tools (e.g. databases) that aim to promote interaction and knowledge sharing are considered as indirect, enabling knowledge management instruments.

2.3.2 Peculiarities of industry-academia knowledge relations

Industry-academia relations and related knowledge exchange processes have been of special importance in the academic literature of learning and innovation in general, as well as of RIS in specifically.⁷⁹ For several decades, technology policy has aimed to link industry and academia more closely and to intensify interaction and cooperation between the two worlds.⁸⁰ Several objectives and factors are linked to intensified industry-academia relations: 1) the economic exploitation of public investments in higher education through spillovers on the private sector, 2) the increase of firms' competitiveness and innovativeness, especially in the knowledge-based economy and science-based industries, respectively, by gaining access to scientific knowledge and other kinds of resources, as well as 3) public budget constraints that require universities and non-university R&D institutions to seek alternative external sources of income resulting in increased research activities financed by the private sector (Polt et al., 2001).⁸¹ Polt et al. (2001) have developed a heuristic model, which distinguishes three influencing determinants of industry-academia relations (see Figure 8):

- 1) The structure and performance of the private sector (e.g. size, industry and R&D intensity) and the scientific institutions (e.g. types of research institutions such as universities, technical universities and joint industry-university labs, as well as research focus) represent the supply and demand of knowledge, respectively. Affected by existing incentive structures and obstacles, the coherence of demand and supply structures determine the scope and form of industry-academia linkages.
- 2) Framework conditions for industry-academia relations that comprise the legal and regulatory environment, institutional incentives and barriers, regulations of talent mobility and training, as well as public support programmes, intermediary organizations and structures either promote or harm industry-academia linkages. Especially the effects and mechanisms of specific public support programmes and intermediary

⁷⁹ However, it is also acknowledged that science only is one source of firms' innovation active ties. Among others, internal knowledge (e.g. personnel and R&D activities) and market relations (e.g. clients, suppliers, start-ups and customers) also are important sources of novel knowledge in the complex and multi-dimensional model of innovation (Polt et al., 2001; Kujath & Schmidt, 2010; Gilsing et al., 2011).

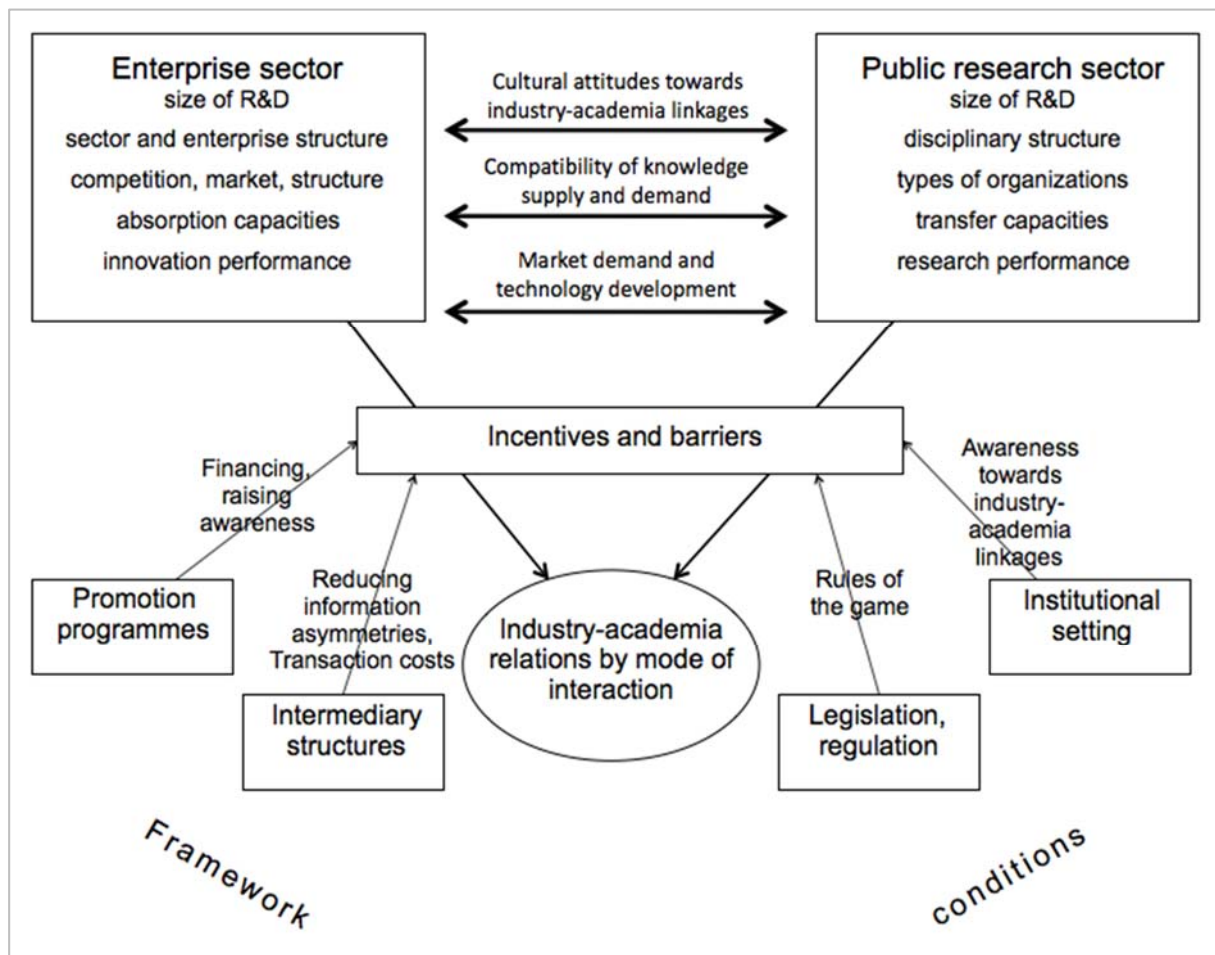
⁸⁰ Governments worldwide support industry-academia knowledge interaction through R&D subsidies, among others (Hewitt-Dundas, 2013). For instance, the German national government has supported formal university-industry cooperation under the label of so-called Verbundforschung since 1984 (Schmoch, 1999).

⁸¹ The concept of the entrepreneurial university linked to the necessity of universities to embody a more entrepreneurial role in the learning economy also underlines this aspect (Etzkowitz & Leyesdorff, 1997; Bercovitz & Feldman, 2006).

structures have been subject of extensive research (e.g. Bozeman, 2000; Agrawal, 2001; Polt et al., 2009).⁸²

- 3) Performance indicators measure the scope and the various dimensions of knowledge interaction between for industry and academia (e.g. informal, formal and HR links).

Figure 8: **Determinants of industry-academia relations**



Source: Polt et al. (2001, p. 251)

Overall, the literature has stressed various significant barriers and obstacles impeding industry-academia knowledge relations and the sharing of knowledge (e.g. Ponds et al.,

⁸² The objectives of instruments and organizations promoting industry-science relations can be summarized as follows: 1) information services about the supply and demand of knowledge and other resources of industry and academia, 2) initiation of informal and formal interaction, and 3) financial support of formalized cooperation projects, talent exchange and spin-off activities (Kröcher, 2005). For example, public support programmes provide financial incentives to businesses and scientific entities to overcome existing barriers in order to foster cross-institutional knowledge exchange. Through the government funding in particular SMEs are able to leverage their R&D funding (Polt et al., 2009; Perkmann et al., 2011).

2007; Boschma & Frenken, 2010).⁸³ Already in the description of institutional proximity in Chapter 2.2.5, I have underlined several fundamental institutional dissimilarities reflected in a lack of shared visions, diverging goals and motivations, varying nature of products, different incentive structures, as well as unequal work practices that hinder the successful creation and realization of industry-academia relationships. Subsequently, the main barriers of productive industry-academia knowledge interaction that have been identified in the literature are summarized.

Firstly, the objectives and the nature of end-products of businesses and academia typically differ from each other. Firms aim to develop concrete applications and technologies in terms of marketable products and services, but also innovative approaches to problem solving. In contrast, academic work usually is complex, ambiguous, and abstract. Scientists aim to develop new knowledge about scientific concepts, models, empirical findings and methodological techniques, which can be disseminated in the academic community. Whether the research outcome has got a commercial value often is not of importance (Cyert & Goodman, 1997). Consequently, a firm's motivation typically diverges from the interests and incentive schemes of universities and other research institutions. Whereas businesses seek to commercialize exclusive technological knowledge in terms of new innovative products and processes as quickly as possible in order to create economic profits and competitive advantages, universities aim to contribute to the public knowledge domain and increase their academic reputation via the dissemination of obtained research results in publications (Gilsing et al., 2011). Furthermore, firms usually operate in a short-term deadlines based environment, as they develop and produce new products and services in response to market forces. In contrast, academic work often is not bound to specific deadlines and much time can pass between project initiation and product development (Cyert & Goodman, 1997).

Secondly, cognitive distances in terms of different or unrelated knowledge bases and the lack of absorptive capacity also is detrimental to effective communication and, in turn, knowledge sharing. In this respect, the knowledge provided by scientific institutions has to be of value to firms and has to meet their specialized knowledge demands, respectively. Thus, too general and theoretical scientific knowledge, which lacks sufficient specificity and

⁸³ Generally, it can be distinguished in four types of obstacles harming interaction between firms and scientific institutions: 1) barriers of not knowing (e.g. information deficits about knowledge, availability of resources and contact persons), 2) barriers of not being able (e.g. lack of absorptive capacity, as well as financial, organizational and methodological resources), 3) barriers of not wanting (e.g. prejudices, high costs, status quo thinking and other priorities), and 4) barriers of not being allowed (e.g. lack of flexibility due to rigid organizational structures and decision-making processes) (Saxony Economic Development Corporation, 2008; Polt et al., 2009).

can easily obtained from other sources, may impede knowledge relations between firms and academia (Polt et al., 2001; Gilsing et al., 2011).⁸⁴

Thirdly, a lack of personal contacts to similar, complementary and diverse knowledge sources harms the probability of access to new relevant knowledge and ideas. Personal links, based on mutual experiences, are often reliable sources for industry-academia knowledge relations. A large variety of such ties increases the accessibility of appropriate external knowledge (Battistella et al., 2016). Closely linked, a lack of trust is an additional major reason collaborations fail in general. Trust between involved actors entails several dimensions, as outlined in Chapter 2.2.2.⁸⁵ Also in industry-academia relations, trust is fundamental to create openness for the sharing of tacit and confidential knowledge (Nooteboom, 2002).

Fourthly, the risk of unintended knowledge spillover is considered another major obstacle that inhibits firms from engaging in knowledge transfer with academia. This risk tends to be even greater than in collaborative activities with (competing) firms. Knowledge interaction with research institutions and universities does not lead to direct free-riding as such, but leaked information and knowledge to academia are very likely to be disseminated publicly, for instance, within scientific networks (Gilsing et al., 2011).⁸⁶

Fifthly, a lack of or ineffectively performing knowledge transfer services and instruments provided by specialized intermediary organizations are identified as additional obstacles of successful knowledge interaction between firms and academia (Saxony Economic Development Corporation, 2008; Polt et al., 2009).⁸⁷ As an illustration, Schmoch (1999) and Fritsch et al. (2007) have found that German university technology transfer offices (TTO) predominantly do not meet the expectations in improving knowledge exchange between universities and industry. Instead of being actively engaged in university-industry

⁸⁴ However, distinct scientific areas appear to converge well with specific industries and economic sectors. Applied and engineering-related research is strongly integrated in various engineering-related industries, but also basic research is strongly applied in industries characterized by a prevalence of basic research, for example, in pharmaceuticals and chemicals (Gilsing et al., 2011).

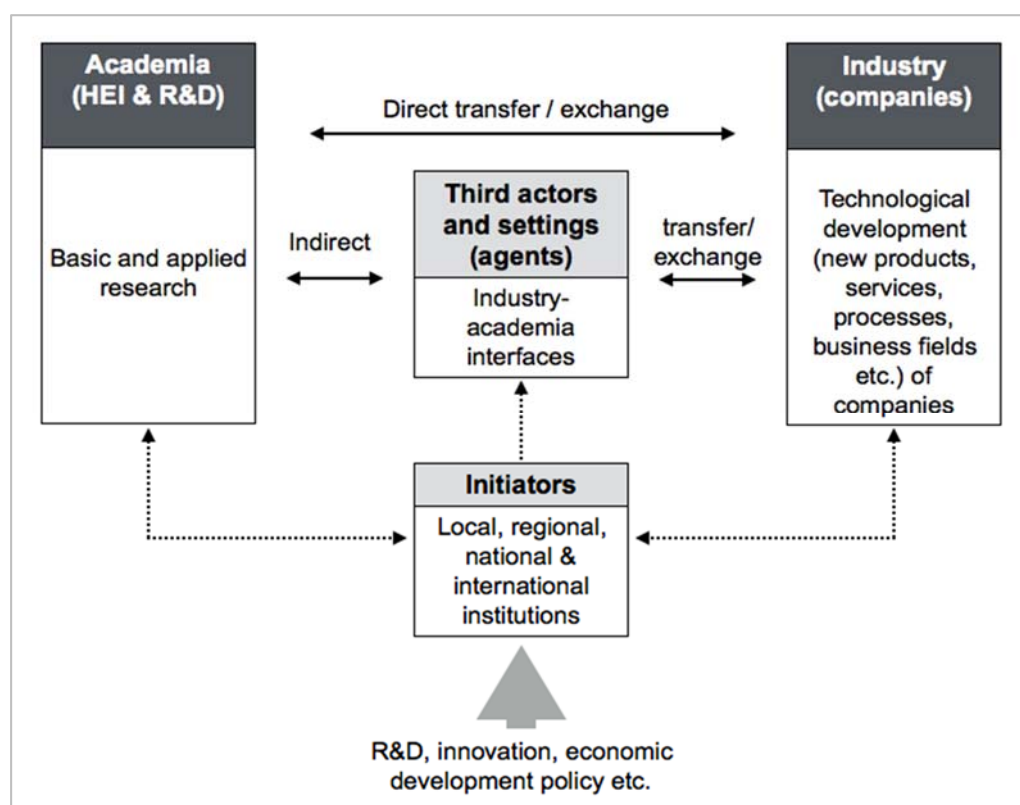
⁸⁵ Accordingly, trust refers to the belief towards the partner's honest motivations and fair actions (i.e. accuracy of information and willingness to share required information), as well as in the partners' capabilities to meet the defined obligations.

⁸⁶ As a consequence, confidentiality and defined regulations regarding intellectual property ownership often are mandatory in such inter-organizational cooperation (Van Looy et al., 2003).

⁸⁷ In the literature, primarily public and university-based TTO, regional development agencies, Chambers of Industry and Commerce (CIC), Industrial Liaison Offices, STPs, incubators and innovation centres are regarded as intermediaries between the private sector and the scientific community (Youtie & Shapira, 2008; Battistella et al., 2016). Additional instruments and services assisting in knowledge exchange processes between industry and academia are outlined in the next chapter and for the STPs examined in Berlin and Seville in Chapter 3.1.

technology and knowledge transfer processes (including patenting and licensing), most of them primarily focus on PR activities in practice. Also, TTO often lack the capabilities and experience in working with industry. In addition, the weak performance as active knowledge transfer intermediaries is primarily allocated to limited resources regarding TTO's staff and budget in relation to the often very large scope and high quantity of research carried out at universities.⁸⁸ Also, the effectiveness of public programmes promoting industry-academia linkages appears to vary significantly. A programme's design, implementation, management and underlying mechanisms to overcome specific barriers in distinct compositions of industry-academia linkages are identified as success criteria, which are specific to each public programme (Polt et al., 2001). Figure 9 illustrates the anticipated role of specialized third actors and settings such as TTO and public support programmes as facilitators of knowledge sharing processes between the private sector and scientific institutions, often installed within the framework of territorial innovation, technology and economic development policies.

Figure 9: **Model of direct and indirect industry-academia knowledge relations**



Source: Author (based on Saxony Economic Development Corporation, 2008)

⁸⁸ Siegel et al. (2003c) have also underlined the need to improve the university TTO's management (including the reward system) by enhancing the staff's capabilities and adapting related university policies. In addition, Polt et al. (2009) have emphasized that the tasks and responsibilities of TTO in Germany have to be up-graded beyond a brokerage function.

Yet, despite fundamental discrepancies between businesses and scientific institutions in general, the probability of successful industry-academia relations also depends on additional criteria, which are linked to the specific characteristics of firms and industries, as well as scientific institutions (Polt et al., 2001).⁸⁹ Thereafter, various studies have found that start-ups, of which many are assumed to be academic spin-offs, and large firms with larger resources by trend are more likely to take advantage of interactive links to public research institutions (Cohen et al., 2002; Fontana et al., 2006; Polt et al., 2009). In terms of economic sectors and industries, Scharfetter et al. (2002) have stressed that SME-dominated industries, as well as industries with high R&D intensity and high talent mobility show a higher probability to engage in knowledge interaction with academia. More specifically, especially R&D intensive manufacturing industries and technical sciences tend to realize direct research cooperation in particular, while service industries and social and economic sciences have the tendency to take advantage of talent mobility and training-related interactions more intensely. Furthermore, multiple scholars have underlined inter-industry differences in manufacturing industries regarding the impact of public research on industrial innovations. Thereafter, public research is an important source for new and innovative products in the pharmaceutical, petroleum, steel, machine tool, semiconductor and aerospace industries in particular. In terms of the impact of specific scientific fields, chemistry has a strong impact on R&D and new products in food, petroleum, metals and chemical industries, biology primarily in pharmaceuticals, and physics predominantly in the semiconductor industry. Computer sciences, engineering and mathematics are found to strongly contribute to R&D activities in a broad set of manufacturing and engineering-related industries, for example, automotive, aerospace and computer industries (Cohen et al., 2002; Mowery & Sampat, 2005; Polt et al., 2009; Gilsing et al., 2011).⁹⁰ In terms of university-industry ties in particular, university departments in natural sciences, technical sciences, agricultural science and economics tend to show higher levels of interaction with the private sector than those in medicine, social sciences or the humanities (Scharfetter et al., 2002).

⁸⁹ For the former, the Saxony Economic Development Corporation (2008) has distinguished four general types of SMEs' readiness towards knowledge interaction with academia in general; 1) SMEs geared towards knowledge transfer, 2) SMEs interested in knowledge transfer, 3) SMEs not interested in knowledge transfer and 4) non-innovators.

⁹⁰ The pharmaceutical and chemical industries are characterized by basic research and a strong dependency on scientific knowledge, for example, in biology, chemical engineering, chemistry and medical science. In this case, especially scientific publications, patent texts, academic spin-offs and consultancy by academic staff are important modes of knowledge transfer. In contrast, engineering-oriented industries, which are primarily characterized by applied knowledge, scientific partners only are part of a broader portfolio of external knowledge sources, also including suppliers and customers. In this case, industry-academia knowledge exchange is primarily realized through joint R&D projects, participation in conferences, professional networks and the hiring of PhD graduates (Gilsing et al., 2011).

2.3.3 Knowledge management in local and regional innovation systems

The management of knowledge creation and organizational learning on the scale of regions was first stressed in the concept of the learning region (Florida, 1995; Morgan, 1997). The concept of the learning region highlights the increasing need for regions to adapt to the same criteria of competitiveness and innovativeness in the learning economy as knowledge-based companies; new ideas, knowledge creation and continuous organizational learning. Hence, regions' competitive advantage in the knowledge-based economy is defined by "their ability to mobilize and to harness knowledge and ideas" (Florida, 1995: 532).⁹¹ As a response to these challenges, learning regions typically promote organizational learning in high-technology and knowledge-based industries, as well as cross-sectoral and cross-institutional learning through the implementation of diverse innovation governance mechanisms and the coordination of flexible networks of a manifold set of regional innovation actors, namely companies, higher education institutions, public and private research organizations, public administration, as well as business associations and chambers (OECD, 2001; Hassink, 2005).

However, the applicability of knowledge management systems and instruments to the context of geographically defined innovation systems and networks such as knowledge regions, knowledge cities and science parks has only recently gained attention in the academic discussion. Kujath (2008) has defined territorial knowledge management as a supporting instrument to organize spatially defined "knowledge networks between different firms, universities and other knowledge carriers in order to support the development of a locality of learning" (Kujath, 2008: 17).⁹² In this respect, the management of territorial knowledge networks is considered a part of national, regional or local economic, industrial, research and innovation policy (Kujath, 2008).⁹³

⁹¹ Florida (1995) has also argued that learning regions provide the fundamental inputs to cope successfully with the challenges posed by the learning economy. In addition to a manufacturing infrastructure, a talent infrastructure to provide and continuously train skilled talent, a physical and communication infrastructure enabling the global connectedness of goods and information, as well as allocated capital allowing the growth of technology and knowledge-oriented industries, specific governance mechanisms must be installed that cater to the needs of knowledge organizations.

⁹² Kujath and Schmidt (2010) have indicated knowledge management in the geographical context as spatial and relational platforms and transfer channels, which coordinate and harness knowledge networks and the combination of existing expertise of diverse knowledge organizations in distinct territorial areas of innovation and localities of learning.

⁹³ Sternberg (1995) has defined technology policy as a comprehensive set of public measures and actions that support and promote the development of new technologies, as well as the commercial exploitation and use of existing and new technologies. Technology policy is considered as intersection between innovation, research and industrial policy.

Several empirical studies have examined the effect of individual knowledge management tools in different contexts of TIS and localities of learning, respectively, including science parks (e.g. Lazaric et al., 2004; Fukugawa, 2006), regional innovation networks (e.g. Harmaakorpi & Melkas, 2005), knowledge cities and regions (e.g. Kostiainen, 2002; Mal-
ecki, 2010), as well as large-scale industrial clusterings (e.g. Dahl & Petersen, 2004; Cooke & Morgan, 1993).

In case of Silicon Valley, Dahl and Pedersen (2004) have highlighted the supporting role of social networking services including trade fairs, conferences, seminars and social activities provided by intermediaries in order to promote informal personal contacts and encourage the sharing of market and technical information. Cooke and Morgan (1993) have underlined the importance of specific regional public institutions and government programmes, for example, Steinbeis Foundation's technology centres and the Chamber of Commerce and Industry, in the Baden-Württemberg innovation system that act as intermediaries and knowledge brokers in terms of enabling and mediating the transfer of state of the art technologies from research institutions to industry in order to sustain the SMEs' global competitiveness.⁹⁴ In the example of loose multi-actor innovation networks in the Lahti region, Harmaakorpi and Melkas (2005) have described the creation of a complex knowledge management system, which closely corresponds to the SECI model of Nonaka (1991), to support collective learning.⁹⁵ The model refers to the application of specific knowledge management tools responding to the specific stages of knowledge creation and required types of ba (see Table 4). The Lathi-based model particularly stresses installed instruments to facilitate personal interaction and to increase trust in order to foster knowledge creation and learning within the regional innovation network. Also, the definition of a mutual knowledge vision is emphasized to set the direction for the knowledge-creating process and to help the diverse multi-actor regional innovation network "in creating and obtaining

⁹⁴ Intermediaries, also referred to as knowledge brokers and boundary-spanners, facilitate transactions between previously unrelated actors lacking trust or access to each other (Hargadon & Sutton, 1997). The concept is derived from transaction cost economics (Nooteboom, 2001). Third parties, who act as intermediaries in inter-organizational knowledge exchange, take over a very complex function. They extend an organization's internal resources regarding the identification and validation of suitable external knowledge sources holding knowledge searched and required, in initiating and mediating the development of functional, trustful relations, as well as in coordinating the actual knowledge interaction process. Thus, intermediaries significantly reduce transaction costs and uncertainty. As indicated earlier, in particular public and university-based technology transfer offices (TTO), Chambers of Industry and Commerce, as well as economic development agencies are underlined as such boundary-spanning organizations (Howells, 2006; Cantner et al. 2011; Battistella et al., 2016).

⁹⁵ Harmaakorpi and Melkas (2005) have added self-transcending knowledge, which is defined as tacit knowledge prior to its embodiment (i.e. sensing the presence of a certain potential), as an additional type of knowledge in their model (in addition to explicit and tacit knowledge).

knowledge in the right amount, at the right moment and in the right form” (Harmaakorpi & Melkas, 2005: 656).⁹⁶

Table 4: Knowledge management sytem in Lahti regional innovation network based on SECI model

Phases of ba	Knowledge types	Knowledge management instruments
1. Visualization / imagination ba	Self-transcending knowledge -> tacit knowledge	Forecasts, scenarios and expert-based interviews to identify hidden trends and potentials
2. Socialization / originating ba	Tacit knowledge -> tacit knowledge	Informal networking events and social meetings to increase social cohesion and trust among actors in the core innovation network, e.g. study trips and team-building events (optional: thematic alignment towards specific target groups)
3. Externalization / interaction ba	Tacit knowledge -> explicit knowledge	Thematic seminars with sharing of new information and knowledge, as well as moderated and documented brainstorming and idea-development platforms and forums to facilitate collective learning
4. Combination / cyber ba	Explicit knowledge -> explicit knowledge	Internet-based platforms for the combination of explicit knowledge (e.g. project plans, meeting minutes, research reports and best practices), including external knowledge
5. Internalization / exercising ba	Explicit knowledge -> tacit knowledge	Thematic group education with strong emphasis on practical exercises and exchange of experts between organizations
6. Potentialization / futurization ba	Explicit knowledge -> self-transcending knowledge	Delphi techniques and forecasts

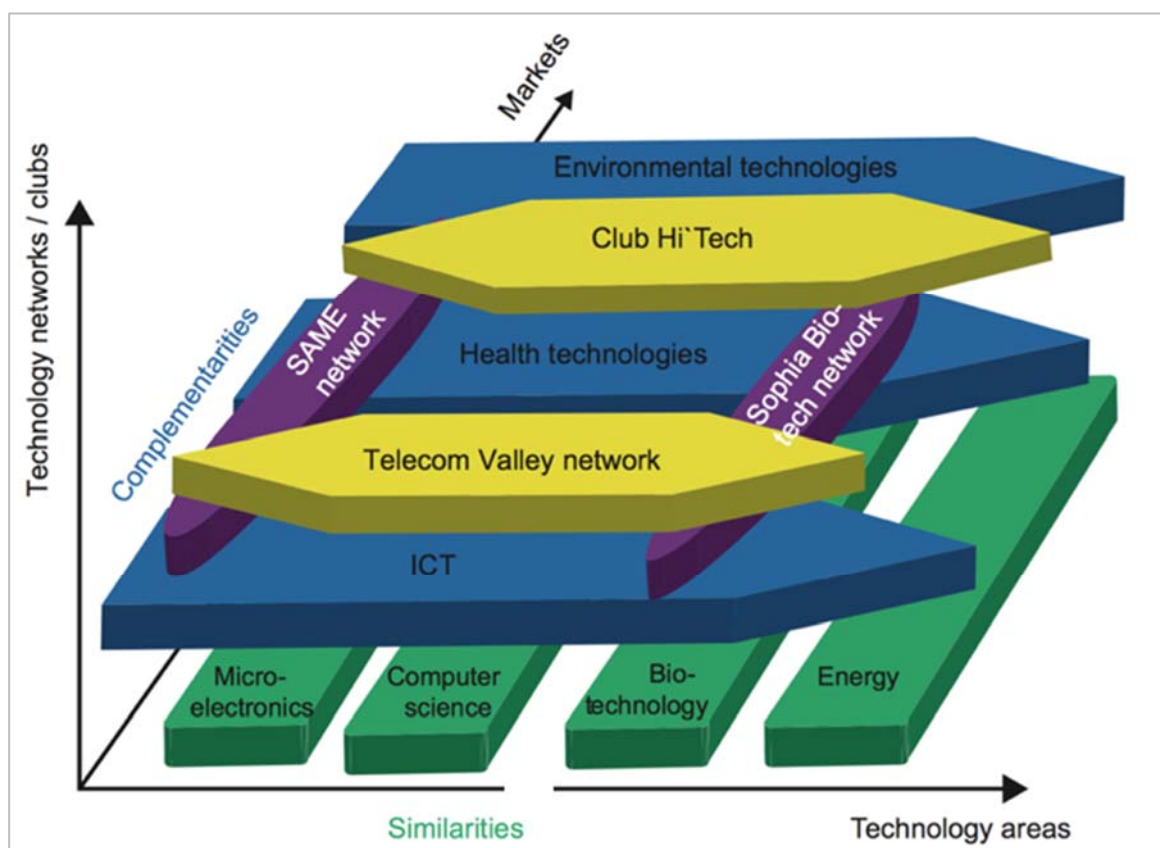
Source: Author (based on Harmaakorpi & Melkas (2005))

⁹⁶ Harmaakorpi and Melkas (2005), however, have not provided any empirical results about the model's effects, sustainability and replicability.

Finally, Lazaric et al. (2004, 2008) have found evidence for enhanced trust, reduced cognitive distance and jointly created knowledge about markets and potential innovation opportunities in the ICT cluster of firms and scientific institutions in the Sophia-Antipolis technopole that have been actively stimulated by IT-based knowledge management. Firstly, a semantic web service mapped and codified the competencies across actors in the local cluster to facilitate the identification of demanded knowledge.⁹⁷ Secondly, the active integration of the heterogeneous actors in the transparent presentation of technological, scientific and entrepreneurial resources in conjunction with an increasing awareness of potential knowledge combinations has enabled the development of a shared language and, thus, the reduction of cognitive distance. Reduced cognitive distance, in turn, has allowed local cluster members to benefit “from both Marshallian externalities (exploitation of the same technological trajectory) and Jacobian externalities (exploration of new combinations)” (Lazaric et al., 2008: 849). Furthermore, intense interaction around prototype design and codification of actors’ competencies has also led to the emergence of epistemic communities and the creation of certain knowledge externalities that set potential for further collaborative activities, for example, the identification of potential knowledge combinations and for interactive innovation opportunities. As a result, IT-based knowledge management has contributed to “organize proximities” (Lazaric et al., 2004: 22) and to generate a shared space for enhanced knowledge interaction and interactive learning in two ways; by mapping the local ICT value added chain and by integrating all relevant local ICT stakeholders into this process (Lazaric et al., 2004, 2008). Also for the Sophia-Antipolis technopole, Longhi (1999) and Lazaric et al. (2004) have stressed the positive effects of specifically aligned business networks and clubs on localized knowledge relations. While specific business associations aim to link actors in complementary markets, others are designed to connect resident organizations and knowledge carriers in specific areas of technology and knowledge (see Figure 10).

⁹⁷ In order to make the ICT cluster’s firms’ and research institutions’ heterogeneous knowledge and competencies comprehensible and comparable, a standard set of information covering various topics, namely key resources, deliverables, business activity, patents, publications, as well as R&D and industrial collaborations, was recorded (Lazaric et al., 2008).

Figure 10: **Specialized business networks in Sophia-Antipolis' ICT cluster**



Source: Lazaric et al. (2004, p. 21) (modified by author)

Overall, selected studies have primarily focused on individual support instruments linked to specific categories of knowledge management instruments; information management (e.g. Lazaric et al., 2004; Lazaric et al., 2008), people management (e.g. Dahl & Pedersen, 2004; Lazaric et al., 2004) and external structures (e.g. Cooke & Morgan, 1993).⁹⁸ The work of Harmaakorpi and Melkas (2005) represents one of the few studies of a comprehensive knowledge management system being applied to a regional multi-actor knowledge network. However, to date a comprehensive (quantitative and qualitative) evaluation of the effects and underlying mechanisms of comprehensive knowledge management systems in distinct localities of learning such as STPs has not been carried out (see Box 5).

In conclusion, the central question for designated seedbeds of innovation such as STPs is how knowledge management systems have to be orchestrated to organize proximities effectively, that is, beyond merely geographical co-location in order to tap knowledge sources

⁹⁸ Most of the mentioned tools (e.g. awareness raising, networking and brokerage) are considered universally in the academic discussions of knowledge management, micro-level network governance, as well as cluster and technology policies (Boekholt & Thuriaux, 1999).

and coordinate knowledge interaction.⁹⁹ As highlighted in Chapters 2.1 and 2.2, this is important to promote local and non-local knowledge interaction and learning among knowledge organizations in general and between firms and academia in particular in order to add to STPs' evolution towards active knowledge-creating and knowledge-coordinating entities in the knowledge-based economy.

Box 5: A working definition of knowledge network management in STPs

In this thesis, I utilize the term knowledge network management (KNM) to describe specialized support mechanisms applied by third actors that aim to facilitate and promote the initiation and cultivation of businesses' egocentric knowledge networks with scientific institutions in the context of local innovation systems such as STPs. The term knowledge network management has been coined by Seufert et al. (1999). It refers to a "proactive, systematic approach to the planning and design of intentional, formalized networks for knowledge creation and transfer, and the establishment of conditions to cultivate emergent, informal networks, widening their scope, guiding them towards high performance, and transferring best practices to other application contexts" (Seufert et al., 1999: 187). Thus in the context of STPs, knowledge network management underlines the active furtherance and organization of cross-institutional knowledge networks (e.g. firms, scientific institutions and other knowledge organizations) in order to promote the development of such planned localities of learning systematically, as also highlighted by Kujath (2008) as well as Kujath and Schmidt (2010).

2.4 Combination of the theoretical concepts and formulation of the research questions

The theoretical concepts and approaches on STPs as designated localities of learning, the proximity framework in knowledge relations and knowledge management applied to territorial innovation systems all provide the basis for the empirical analysis in Chapter 4. Subsequently, the relevant theoretical concepts are summarized and assembled to the analytical framework of this thesis. Finally, I outline the specific research questions, on which this dissertation thesis focuses on.

⁹⁹ Kosttainen (2002) has underlined the need to manage and to cope with diverse knowledge organizations characterized by different cognitive, organizational and institutional backgrounds in regional innovation systems in order to promote collective learning. As I have shown in Chapter 2.3.2, this applies to knowledge relations between industry and academia in particular.

2.4.1 Combination of the theoretical concepts: Proximity dynamics and knowledge network management in knowledge relations in science parks

At the centre of this thesis is the analysis of STP resident firms' knowledge relations to scientific institutions, especially in regard to the underlying distinct types of proximity that assume specific functions in link creation and the realization of knowledge interaction. The conceptual model of STPs as designated seedbeds of innovation with strong links to theoretical approaches of spatial clusterings and innovation systems such as the innovative milieu, Porter's cluster, Marshallian industrial districts and the triple helix, presented in Chapter 2.1, provides the main spatial framework of this thesis. Furthermore, challenges in regard to STPs' function in the globalizing knowledge-based economy have motivated this thesis.

Chapter 2.2 outlines the proximity framework as the main theoretical concept of this thesis. The proximity framework highlights the importance of multi-dimensional proximity, i.e. cognitive, social, organizational, institutional and geographical proximity, in knowledge interaction. Furthermore, specific configurations of multi-faceted proximity apply to the heterogeneous forms of inter-organizational knowledge relations.

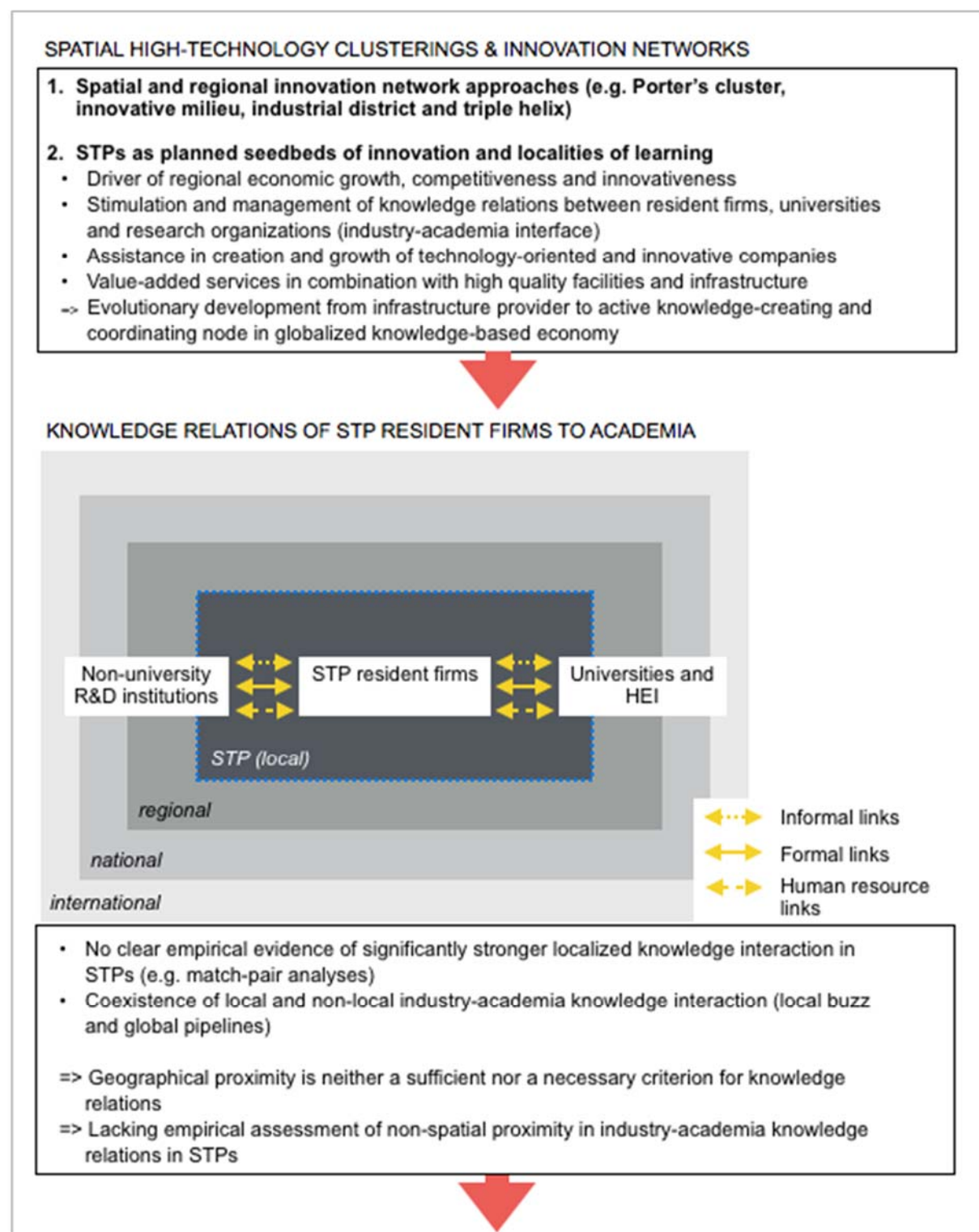
Both chapters 2.1 and 2.2 highlight that geographical proximity is neither a sufficient nor a necessary criterion for the successful creation and realization of industry-academia knowledge relations. Instead, other non-spatial and relational types of proximity are necessary and critical for the initiation and implementation of the STP resident companies' knowledge ties with scientific institutions. The identification of different types of knowledge seeking-companies in this thesis allows for the further specification of the responsible factors and relevant proximity configurations of successful knowledge relations between technology-oriented firms and academia.

In addition to the structure, geography and specific proximity configurations of STP resident businesses' egocentric knowledge networks to scientific institutions, the applicability of so-called knowledge network management (KNM) – as an external governance and steering element – to coordinate and harness industry-academia knowledge relations in STPs and on the supra-local scale systematically is examined. Chapter 2.3 describes the concept of knowledge management, which is strongly applied in the context of organizational and inter-organizational learning. Also, the external support of knowledge sharing and learning processes in territorial innovation systems and networks is increasingly gaining attention. Therefore, the influence of knowledge network management systems applied in STPs on

the organization of distinct dimensions of proximity in industry-academia knowledge relations is investigated.

As a result of the different theoretical concepts and the empirical analysis of STP resident firms' knowledge relations to academia and related underlying factors, specific policy recommendations for the effective design and orchestration of knowledge network management systems of STPs and other innovation systems and habitats can be formulated (see Figure 11). Such governance mechanisms aim to add to the STPs' evolution towards active and pivotal knowledge-creating and knowledge-coordinating entities in the knowledge-based economy.

Figure 11: **Nexus of the theoretical concepts and research approaches**



PROXIMITY FRAMEWORK IN KNOWLEDGE INTERACTION

Hierarchy of non-spatial and spatial types of proximity

- Cognitive proximity (knowledge gap): essential function
- Institutional proximity (trust based on shared institutions): critical enabler
- Organizational proximity (control mechanisms): critical enabler
- Social proximity (embeddedness and trust): critical / auxiliary factor
- Geographical proximity (physical distance): auxiliary factor

=> No universal and industry-specific proximity configuration

=> Constant process of trade-offs and proximity adaptation



APPLICATION OF KNOWLEDGE MANAGEMENT TO SPATIAL INNOVATION SYSTEMS

- Active management and steering of organizational and inter-organizational learning
- Different processes of knowledge management (knowledge identification, creation and acquisition, storage and retrieval, internal and external sharing, and application)
- Typology of knowledge management instruments:
 - Information management
 - People management / social systems
 - External structures
- Application to local and regional innovation networks to "organize proximities" (Lazarcic et al., 2004: 22) for successful knowledge relations between industry and academia



POLICY IMPLICATIONS

Design of effective knowledge network management systems in STPs, and other territorial innovation systems and networks:

- => Value added structures and services to facilitate and support enhanced industry-academia knowledge relations and learning
- => Complying with anticipated role of STP as active knowledge-creating and knowledge-coordinating actors in the globalizing knowledge-based economy

Source: Author

2.4.2 Research questions

Chapter 1 outlined the overall objectives of this doctoral thesis. Subsequently, the relevant theoretical concepts in relation to STPs as designated seedbeds of innovation, the proximity framework in knowledge relations and the applicability of knowledge network management to the context of local and regional innovation systems, presented in Chapters 2.1 to 2.3, have resulted in the development of specific research questions concerning the underlying proximity dynamics of industry-academia knowledge relations and their concerted management in STPs. As a result, the following research questions are central to the analysis of this thesis:

1. What knowledge relations to academia are evident for the STP resident firms in the selected science parks?

- What modes of interaction are utilized (informal, formal, HR related)?
- On what geographical scales (local, non-local) do resident high-technology businesses maintain knowledge relations to scientific institutions?

2. What types of firm-centred knowledge networks to academia can be identified?

- How are the firms' knowledge relations to academia in the specific types characterized?

3. What are the influencing factors enabling and driving knowledge interaction with academia both in the STP and external to the STP?

- Which firm-specific and external channels and settings facilitate the formation and realization of STP resident firms' knowledge relations to academia on the local and extra-local scale?

4. Which dimensions of proximity matter in a firm's knowledge relations with academia?

- What is the role of non-spatial and spatial proximity in local and extra-local industry-academia knowledge relations?
- What specific proximity configurations can be identified?

5. To which extent do knowledge network management systems in STPs create and organize proximity to stimulate industry-academia knowledge relations?

- What types of proximity are organized by the specific knowledge network management instruments?

In the next chapter, the operationalization and the methodology of the research project is outlined. It includes the description of the two case studies, the Berlin-Adlershof and Seville-Cartuja science and technology parks, as well as the methodology of the empirical analysis.

3. Operationalization and methodology of the research project

In this chapter, I introduce the operationalization and the methodology of the research project. It includes the presentation of the two science parks Berlin-Adlershof and Seville-Cartuja, as well as the description of the empirical methodology.

3.1 Selection of the science park case studies

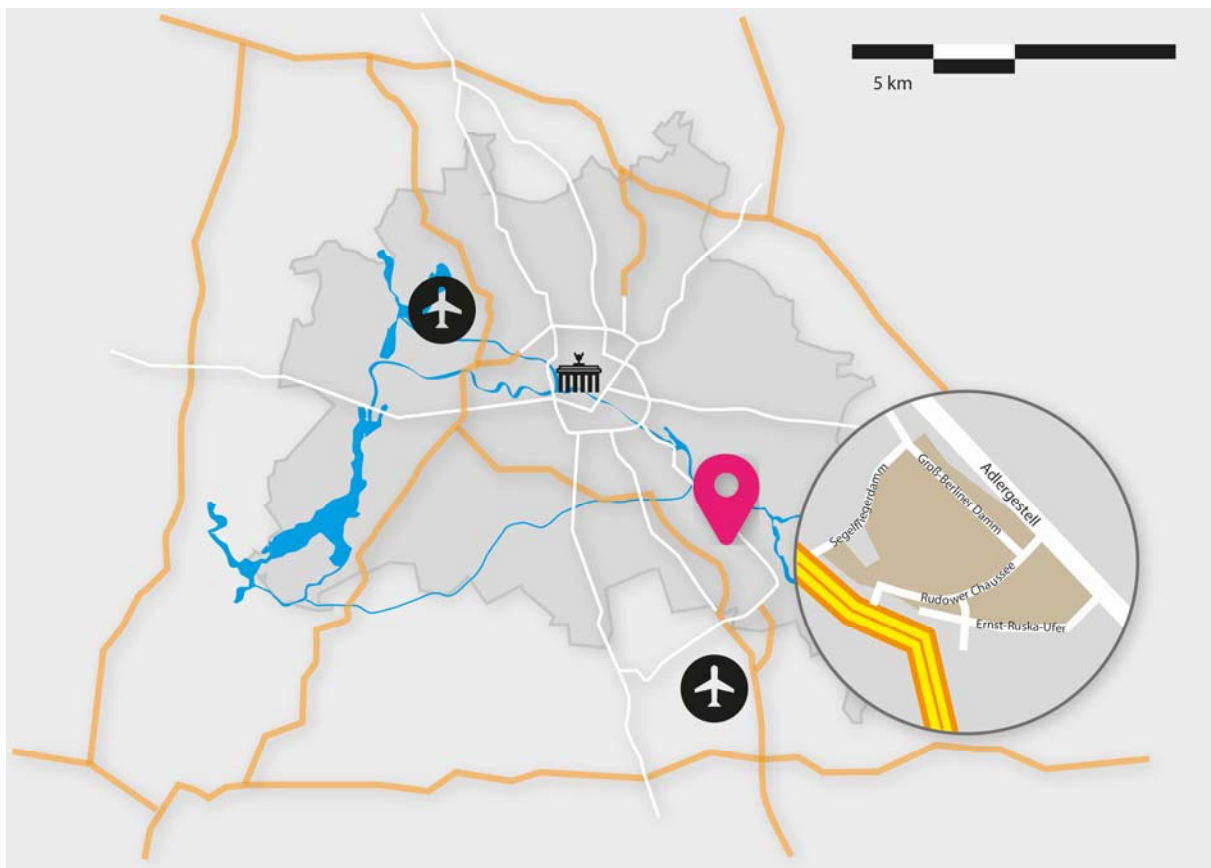
This chapter briefly outlines the distinct characteristics of the two STP case studies I selected for my empirical analysis: Berlin-Adlershof in Germany and Seville-Cartuja in Spain. The two STPs in Berlin and Seville were selected for the following reasons: they are located in a metropolitan area; they have an analogous composition of local stakeholders from the regional triple helix (industry-academia-government); and they have an almost identical level of maturity. In addition, both STPs showcase similar sets of knowledge network management instruments that have been installed locally or are accessible to the STPs' resident firms and scientific institutions. Subsequently, I elaborate on the two STPs' objectives, development and contextual environment in order to better understand the structure and quality of localized knowledge interaction and related support services, as highlighted by Bigliardi et al. (2006).

3.1.1 Berlin-Adlershof Science and Technology Park

The Berlin-Adlershof science park is situated in the southeast of Berlin in the city district of Treptow-Köpenick (see Figure 12). The distance to the Berlin city centre is about 15 km.¹⁰⁰

¹⁰⁰ Berlin is the largest city in Germany. In 2015, about 3.52 million inhabitants were recorded (Statistical Office for Berlin-Brandenburg, 2016).

Figure 12: **Location of the Adlershof science park in Berlin**



Source: Author (based on Google Maps, 2017)

The Adlershof Science and Technology Park was founded in 1991. To date, 1,013 companies, six natural science departments of the Humboldt-Universität zu Berlin (HU-Berlin) and ten non-university research institutions are located at the site.¹⁰¹ Approximately 495 high-technology companies primarily operate in the following six key technology areas: optics and photonics, material and micro system technologies, ICT, biotechnology and environment, energy and photovoltaics, and analytics. About 100 companies are located in the science park's two incubators. In total, ca. 15,940 employees work in the science park, about 13,210 of them in companies and ca. 2,730 at the university and non-university research institutions. Furthermore, roughly 6,520 students study in the science park. In 2015, all resident organizations generated a total of €1.89 billion in turnover and funding (WISTA-MANAGEMENT, 2016a, 2016c).¹⁰² The OECD (2010) has ranked the Adlershof science

¹⁰¹ Figure 16 provides an overview of the scientific institutions located in the Adlershof science park.

¹⁰² In the time period of 2010-2011, in which the empirical research was conducted, 905 companies, of which 429 were considered high-technology companies, six natural science departments of the Humboldt-Universität zu Berlin and eleven non-university research institutions were located in the STP Adlershof. The total employment was ca. 14,970 persons (excl. trainees), of which ca. 12,140 employees worked in the private sector and ca. 2,830 in the scientific institutions. Furthermore, roughly 8,030 students were record-

park among the 15 largest science and technology parks worldwide and has named it as one of the most successful high-tech locations in Germany.

Figure 13: **STP Adlershof today**



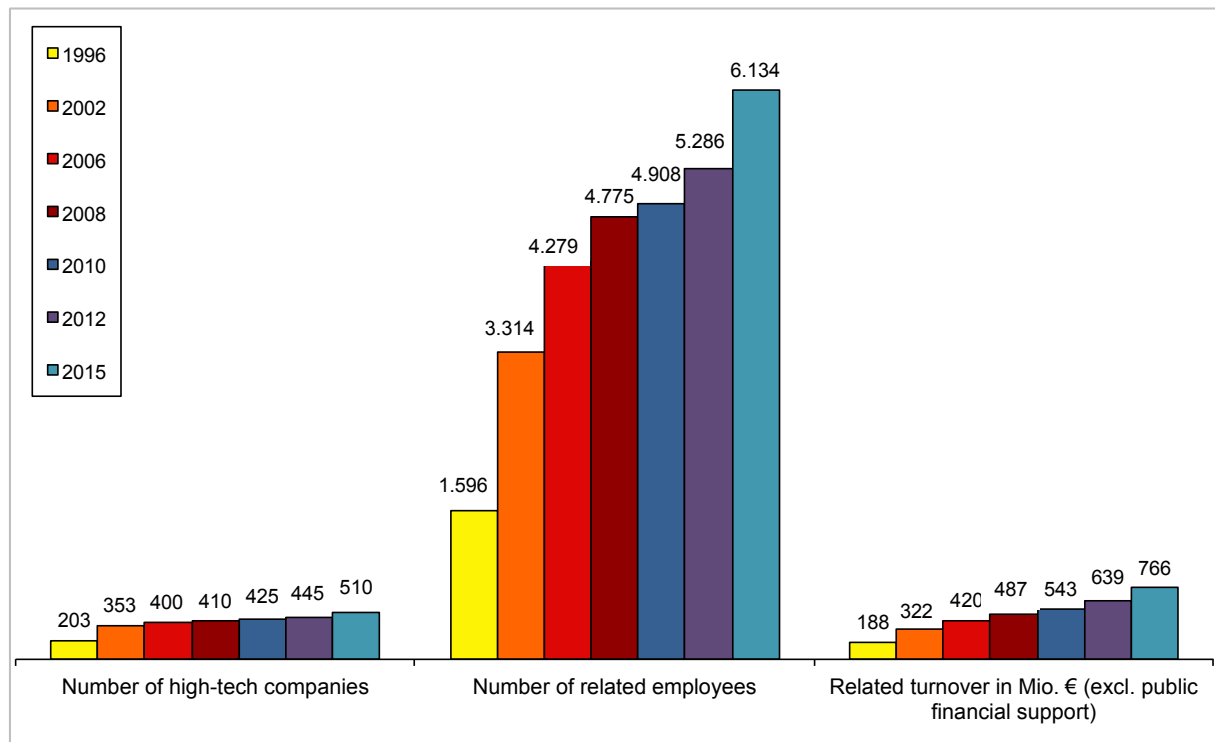
Source: Author

The large majority of the businesses are micro and small businesses, based on the SME definition of the European Commission (European Commission, 2016).¹⁰³ In particular, technology-oriented and science-based companies have shown a dynamic growth in terms of employment and turnover (see Figure 14), while also insolvency rates of start-up firms have been very low in the past (Kulke, 2008; Raetz, 2008).

ed on-site. The resident organizations' total turnover, budgets and public funding summed up to about €1.61 billion (WISTA-MANAGEMENT, 2012a).

¹⁰³ For 2010, WISTA-MG reported the following structure of high-technology firms in the STP Adlershof: ca. 65.5% with less than 10 employees (i.e. micro firms), ca. 28.5% with 10-49 employees (i.e. small firms) and ca. 6% with more than 50 employees (i.e. medium-sized firms) (expert interview with WISTA-MG, 30 September 2011).

Figure 14: **Development of technology companies in Adlershof, 1996-2015**



Source: Based on WISTA-MANAGEMENT (2006a, 2007, 2009, 2011a, 2013a, 2016a)

Until 1990, the site of the Adlershof science park was the largest location of the former GDR's central research institution the Academy of Science (AdW). It comprised 15 associated R&D centres, predominantly in natural sciences (e.g. physics and chemistry) and 5,400 employees at its peak in 1989 (Kulke, 2008).¹⁰⁴ During the course of German reunification, the Academy of Science was liquidated, while its research resources were partly transferred into new or integrated into existing research institutions.¹⁰⁵ Eight of the former Academy of Science institutions that predominantly focused on basic research in natural sciences were integrated into the public, non-university research institutions of the Max-Planck Society, Fraunhofer-Gesellschaft and Leibniz Society. As a result, these R&D institutions absorbed about 30% of the former total employment of the Academy of Science (Mieg & Mackrodt, 2010). In contrast, industry-oriented R&D institutes of the Academy of

¹⁰⁴ In fact, the history of research and sciences in Adlershof even dates back to the beginning of the 20th century. Adjacent Johannisthal being the first airport for engine-powered aircrafts led to the location of several aviation-related production companies and related research institutions (e.g. German Laboratory of Aviation (Deutsche Versuchsanstalt für Luftfahrtforschung), Erich Rumppler Aircraft Construction Company, the Fokker Airplane Factory and Wright brothers) at the site since 1909 (Mieg & Mackrodt, 2010). After the First World War, several automotive companies such as BMW and Austin, as well as motion picture production companies took over the site, as aviation and aerospace related production and research was interdicted. During the Nazi regime, Adlershof became a centre of aviation production and research again (Kulke, 2008).

¹⁰⁵ In 1990, local facilities related to the national television of the GDR were dissolved or privatized, too. Facilities of locally garrisoned armed forces of the GDR were closed (Kulke, 2008; Mieg & Mackrodt, 2010).

Science were predominantly dissolved. The remaining scientists had to find new jobs or start their own companies. As a result, more than 100 new companies were founded by former Academy of Science's employees and also located at the science park (Dannenberg & Suwala, 2009).

After German reunification, the state of Berlin primarily pursued an innovation-oriented and science-led economic development strategy to compensate for the severe loss of employment in the manufacturing sector.¹⁰⁶ As a consequence, several technology parks and incubators, of which the Adlershof science park was the largest and most prominent project, were established in the region.¹⁰⁷ The urban planning concept for the restructuring of the Adlershof site foresaw the creation of an international centre of science, business and media, based on the site's tradition in natural sciences and television. Illustrated in Figure 15, following the model of an integrated city, mixed-uses such as commercial activities, social infrastructure, residential areas and recreation areas were also integrated into the STP's development concept (Kulke, 2008; Mieg & Mackrodt, 2010).¹⁰⁸ In 1991, the development entity Entwicklungsgesellschaft Adlershof mbH (EGA) was founded, which was integrated into the current STP management company WISTA-MANAGEMENT GmbH (WISTA-MG) in 1994.¹⁰⁹ Also in 1991, the first incubator IGZ accommodating five start-up firms with 14 employees was opened on the site (Dannenberg & Suwala, 2009; Kulke, 2013b).¹¹⁰

¹⁰⁶ Due to deindustrialization process, employment in manufacturing in East Berlin decreased by ca. 80%, as the large majority of the companies was not competitive nationally and internationally. Also formerly subsidized manufacturing companies in West Berlin relocated to other locations (Kulke, 2008).

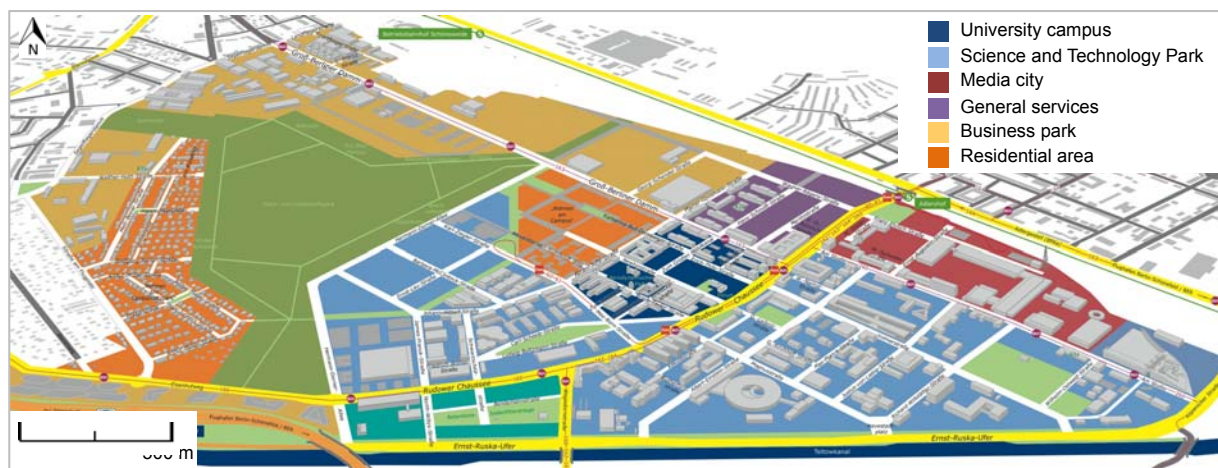
¹⁰⁷ The life sciences oriented STP Berlin-Buch, established in 1992, is another example of such public large-scale innovation infrastructure projects initiated at that time (OECD, 2010).

¹⁰⁸ The media industry is an additional important component of the Berlin-Adlershof science park. In 2015, has encompassed about 140 companies (i.a. motion picture and TV broadcasting production, post-production and related services) with ca. 1,920 employees (WISTA-MANAGEMENT, 2016a).

¹⁰⁹ WISTA-MANAGEMENT GmbH (WISTA-MG) is the responsible science park development and facility management organization. It is a public company, the state of Berlin being the 100% shareholder (WISTA-MANAGEMENT, 2016a).

¹¹⁰ The international incubator OWZ opened in 1997 (Raetz & Seiff, 2003). In addition, WISTA-MG also operates specialized technology centres in the five key technology areas: optics/photonics, micro systems/materials, IT/media, biotechnology/environment and renewable energies/photovoltaics (WISTA-MANAGEMENT, 2016a).

Figure 15: **Layout of the Berlin-Adlershof science park by distinct functions**



Source: WISTA-MANAGEMENT (2012b) (modified by author)

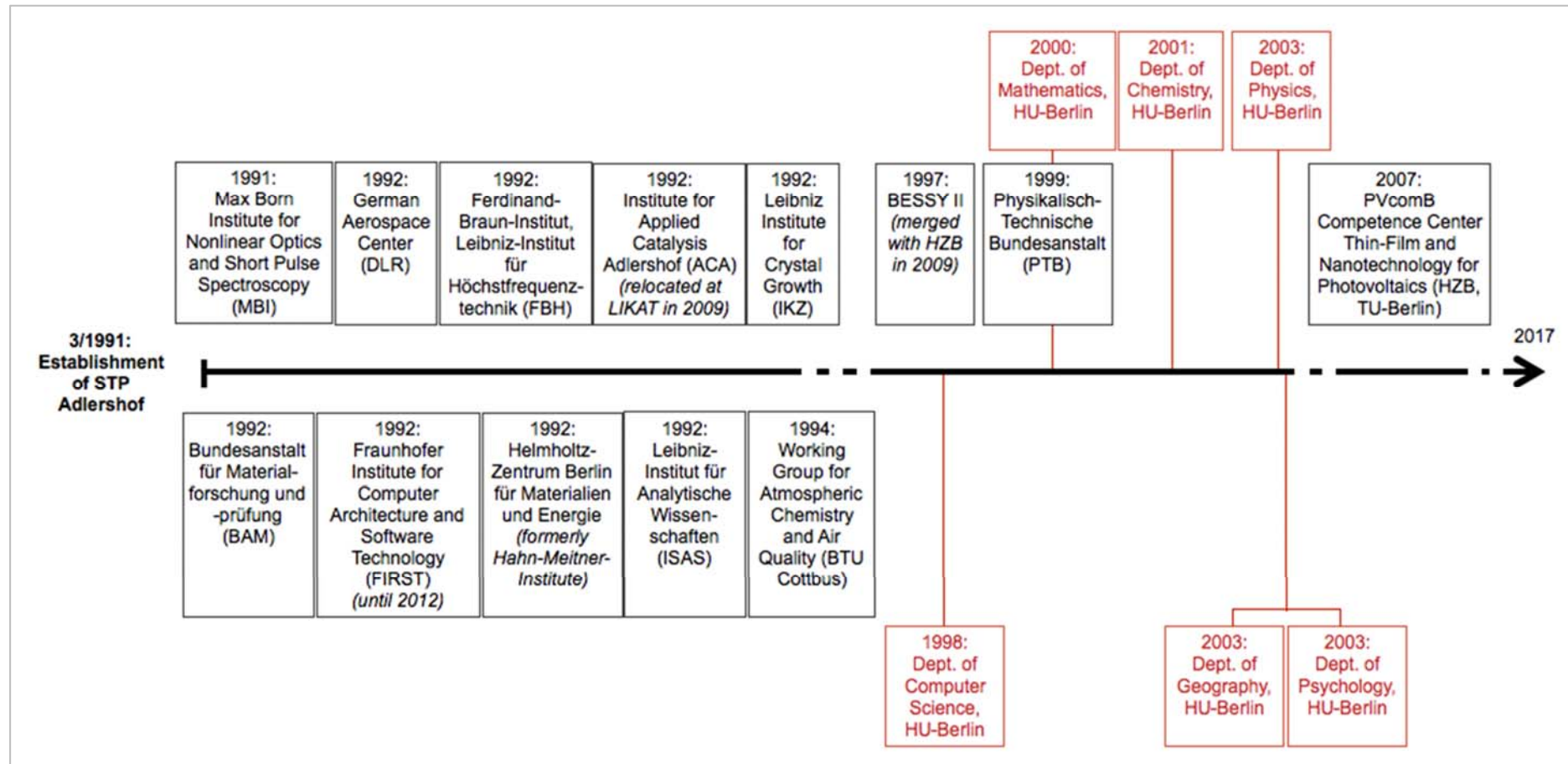
With a strong link to concepts of spatial agglomerations of economic activity and innovation networks such as industrial clusters and innovative milieu, the STP's concept pursued the strategic geographical co-location of complementary entities of universities, R&D institutions and companies. As such, the political decision by the Berlin government and the Humboldt-Universität zu Berlin (HU-Berlin) in 1991 to relocate the university departments of natural sciences to the newly developed science park was significant.¹¹¹ In 2003, the relocation of the Departments of Physics, Geography and Psychology completed the move of the six university departments in total, which had started in 1998, to the STP Adlershof (Kulke, 2008).

Since 1991 and 1992, when the newly aligned non-university research institutions reopened, the attraction of multiple R&D institutions, organizational mergers, but also placements to other locations have resulted in a dynamically changing composition of resident academic institutions.¹¹² Figure 16 provides an overview of the dynamic location process of university and non-university research institutions since 1991.

¹¹¹ Nevertheless, due to internal controversies, among other things, it was only in 1998 when the first of the designated six university departments moved to the new university campus at the Adlershof science park. The six university departments cover the following research areas: computer science, mathematics, physics, chemistry, psychology and geography (Kulke, 2008).

¹¹² BESSY II and Physikalisch-Technische Bundesanstalt (PTB) have located on-site in 1997 and 1999, respectively (PTB, 2017; Senatsverwaltung für Stadtentwicklung und Umwelt, 2013). The Competence Center Thin-Film and Nanotechnology for Photovoltaics (PVcomB) at the HZB was established in 2007 (HZB, 2017). The Institute for Applied Chemistry Adlershof (ACA) merged with the Leibniz Institute for Organic Catalysis to the Leibniz Institute for Catalysis (LIKAT) at the University of Rostock in 2009 (Leibniz Gemeinschaft, 2017). After the empirical analysis was completed in 2011, the Fraunhofer Institute for Computer Architecture and Software Technology (FIRST) left the site in June 2012. It merged with the Fraunhofer Institutes FOKUS and ISST-Berlin under the name Fraunhofer FOKUS, which is now located in Berlin-Charlottenburg (Fraunhofer-Gesellschaft, 2013).

Figure 16: Relocation of scientific institutions at the STP Adlershof since 1991



Source: Author (based on Kulke (2008), expert interview with WISTA-MG (10 July 2015), HU-Berlin (2016))

The concept of the STP Adlershof seeks to complement R&D institutions' and university departments' research areas to the technology areas of resident companies (Kulke, 2008; Dannenberg & Suwala, 2009).¹¹³ However, according to the OECD (2010), the non-university research institutes and the new HU-Berlin natural sciences' university campus were built around selected scientific strengths of the former Academy of Science and purely academic reasons, respectively, and are not specifically linked to the city's and local economic base.

To some degree, empirical research provides corresponding findings. Accordingly, only moderate and rather informal localized knowledge linkages between resident businesses and the institutes of the HU-Berlin have been highlighted in previous studies. In contrast, higher levels of interaction have been identified for resident businesses' ties to the co-located non-university research institutions, which focus on applied research, in particular (Weber-Bleye, 2005; Kulke, 2008; Kulke & Wessel, 2008; Warland, 2011). Denoted as unrelated variety by the OECD (2010), the lack of convergence of local basic university research and companies' market-oriented needs, as well as diverging organizational objectives of SMEs and the local university have been detected as main causes for weak localized interaction.¹¹⁴ Instead, non-local technical universities and universities of applied sciences, especially in the Berlin region, have been identified as more important partners of cooperation (OECD, 2010; Kulke, 2008; Brühöfener McCourt, 2009).¹¹⁵

Nevertheless, a broad range of formal relations (e.g. joint appointments of professors and mutual research projects) between the university and co-located non-university research institutions has developed (Kulke, 2008). Furthermore, multiple scholars have emphasized

¹¹³ In addition, the intentionally designed immediate vicinity of specific organizations and specialized infrastructure, for example, in the field of optics and photonics (e.g. HU-Berlin's Department of Physics, Max-Born-Institute, Leibniz Institute for Crystal Growth and the technology centre for optics and photonics) aims to reinforce the geographical proximity between resident organizations given at the STP Adlershof (WISTA-MANAGEMENT, 2014).

¹¹⁴ The OECD (2010) has underlined that universities of applied sciences are more important sources of knowledge interaction to companies in the Berlin region in general. Two reasons are identified. Firstly, in some cases, basic research oriented universities show low interest in cooperation with regional SMEs. Secondly, the predominant share of SMEs works in more practical-oriented industries, where innovation is more incremental and demand-led. Therefore, they rather seek access to application-oriented scientific know-how.

¹¹⁵ In total, more than 50 public and private universities (including two technical universities and eight universities of applied sciences), as well as more than 100 R&D institutions (including 21 of the three main German research societies Fraunhofer Gesellschaft, Max Planck Society and Helmholtz Association of German Research Centres) with about 50,000 researchers are situated in Berlin-Brandenburg. Furthermore, approximately 225,000 students are enrolled in the region's HEIs (ZAB Brandenburg Economic Development Board, 2017; Statistical Office for Berlin-Brandenburg, 2017; Senatsverwaltung für Bildung, Jugend und Wissenschaft Berlin, 2016). Berlin is the leading centre of scientific production in Germany (Grossetti et al., 2014).

strong social networks and knowledge relations among former researchers of the Academy of Science in particular (Brühöfener McCourt, 2009; Jähnke, 2009). In this regard, Dannenberg and Suwala (2009) have pointed out that about 90% of those who started their own company still cooperate with at least one former co-worker of the Academy of Science, now working in co-located firms or scientific institutions. About 60% of them even do so with at least three former colleagues of the Academy of Science.

Beyond the geographical co-location of the complementary elements of university, non-university research institutions and companies, the STP Adlershof comprises various informal meeting places (so-called third places) such as several restaurants and cafés, sports facilities and a public park.¹¹⁶ However, the STP development concept initially did not include a distinct strategy to foster the formation of interactive linkages or to manage local knowledge networks (Kulke, 2008; Dannenberg & Suwala, 2009).

Knowledge network management system at the Berlin-Adlershof science park

In the meantime, there is now a broad range of locally offered and locally accessible knowledge network management instruments, which aim to facilitate and promote inter-organizational and especially industry-academia knowledge relations on the local scale and in general, at the STP Adlershof. Table 5 names the relevant KNM tools that were detected in 2011.¹¹⁷

Table 5: KNM instruments at the STP Berlin-Adlershof

KNM instruments	Examples
STP-related knowledge marketing	WISTA-MG website, social media and print magazines (Adlershof Journal, Adlershof Special)
Local networking events	Academic Lunch, Business Lunch, Ladies Lunch; WISTA-MG New Year's reception, summer party, Adlershof Colloquium
Locally organized industry and scientific conferences	microsys-Berlin, International Photonics Summer School, Congress for X-ray analytics for industrial processes (PRORA)

¹¹⁶ Oldenburg (1999) has coined the term third places. It refers to publicly accessible physical spaces, where people can gather, meet and interact informally. Examples are cafés, restaurants and public spaces.

¹¹⁷ The list of the exemplary KNM practices named for each category is not exhaustive. Generally, the empirical analysis has incorporated those KNM services and tools that were in place when the empirical analysis was conducted or recently before. A detailed description of the individual KNM organizations and services for the Adlershof case study can be found in Table A6 in the Appendix.

KNM instruments	Examples
Local and regional intermediaries ¹¹⁸	STP management: WISTA-MANAGEMENT GmbH; University TTO: Humboldt-Innovation GmbH (HU-Berlin); Regional innovation promoting entities: Berlin Partner GmbH, Technologiestiftung Berlin (TSB), Berlin Chamber of Industry and Commerce (CIC)
Local formal networks	Technologiekreis Adlershof, Forum Adlershof, OpTecBB ¹¹⁹
Public support programmes for industry-academia R&D projects ¹²⁰	ProFIT, TransferBONUS, ZIM, Innovative regionale Wachstumskerne etc., as well as additional European programmes (e.g. EU Framework Programme for Research and Innovation)

Source: Author

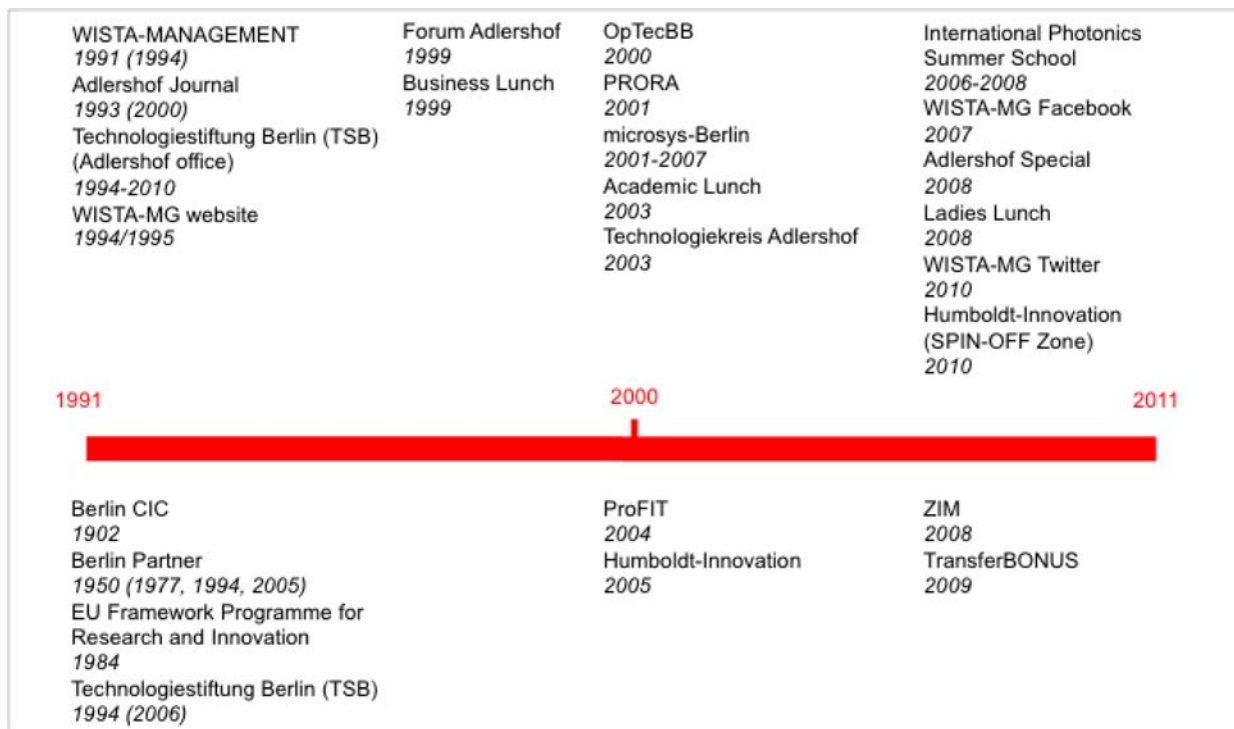
The large majority of the specialized KNM instruments that are installed at the science park have been in operation since 2000. Others like, for instance, the STP management company WISTA-MG, related information services and the local office of the Technologiestiftung Berlin (TSB) already have been in place since the early stages of the STP's development (see Figure 17). More recently, the university's TTO, additional specialized local networking events and social media platforms as part of the STP-related knowledge marketing have been added. In regard to non-locally bound KNM organizations and instruments, regional intermediary organizations such as Berlin Partner (and related predecessor organizations) have been active for many years. In addition, most of the relevant regional and national public support programmes for industry-academia R&D projects were launched between 2004 and 2009.

¹¹⁸ The management company of the two Adlershof-based incubators IZBM GmbH is not included in the analysis, because it only caters to a certain fraction of resident businesses at the STP. Furthermore, the patent commercialization agency of Berlin ipal GmbH also is not included in the analysis, because any equivalent counterpart organization could not be identified for the STP Cartuja case study. The same applies to IGAFa (the association of the non-university research institutions in Adlershof).

¹¹⁹ The Technologiekreis Adlershof and Forum Adlershof are formal networks of Adlershof-based companies, entrepreneurs and scientific institutions (Technologiekreis Adlershof, 2016a; Know-Man, 2011). The network of the optical industry in Berlin-Brandenburg region OpTecBB is also included in the analysis. A large number of Adlershof resident organizations (i.e. companies and scientific institutions) are network members (OpTecBB, 2016a). Also, the network management organization of OpTecBB is located at the STP Adlershof. Multiple studies have examined the network's organizational structure and interdependencies among members (Lerch et al., 2007; Sydow, et al., 2007; Sydow et al., 2011).

¹²⁰ The regional and national government, as well as the European Commission typically are in charge of public support programmes for the coordination of industry-academia R&D projects. Thus, these support schemes are not confined to Adlershof resident organizations, but rather promote formalized industry-academia cooperation on the regional, national and European scale.

Figure 17: **Timeline of KNM instruments at the STP Adlershof (non-exhaustive)**



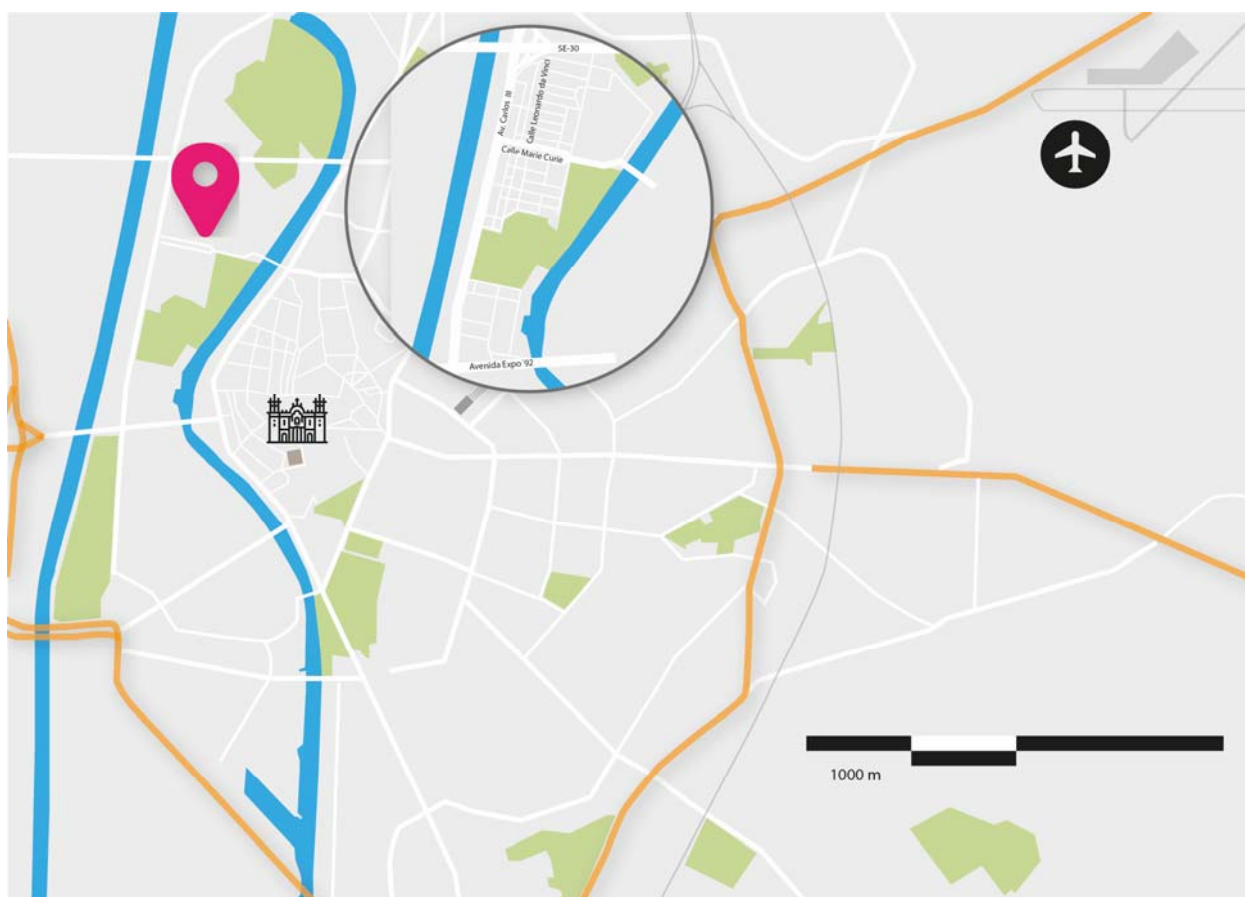
Source: Author (based on *Investitionsbank Berlin* (2009), *Know-Man* (2011), expert interview with WISTA-MG (15 January 2013), *European Commission* (2014) and websites of named KNM instruments, among others – see Table A6 in the Appendix for details)

Until now, few scholars have examined the impact of individual KNM tools empirically. Jähne (2009) and Brühöfener McCourt (2009) have highlighted the role of local networking events (e.g. Academic Lunch) for informal exchange of information and knowledge among Adlershof-based businesses in the life sciences industry. Also, local formal networks (e.g. Forum Adlershof and Technologiekreis Adlershof) have been identified as important facilitators of informal and service-based interaction between resident firms and scientific institutions. However, the influence of the comprehensive set of KNM instruments at the Berlin-Adlershof science park, as outlined in Table 5, on industry-academia knowledge relations has not yet been examined.

3.1.2 Seville-Cartuja Science and Technology Park¹²¹

The Seville-Cartuja Science and Technology Park is centrally situated in the northwest of Seville on a quasi-island in the Guadalquivir River.¹²² The distance to the city centre is about 3 km (see Figure 18).¹²³

Figure 18: **Location of the Cartuja science park in Seville**



Source: Author (based on Google Maps, 2017)

The Cartuja Science and Technology Park was established in October 1993 as the direct consequence of the Expo' 92 World Fair held in Seville from April to October 1992 (Castells & Hall, 1994). To date, about 420 organizations including ca. 210 high-technology compa-

¹²¹ Due to the limited academic literature about the STP Cartuja's development process and local inter-organizational interaction, I also refer to comprehensive material provided by the STP management company Cartuja 93. Also, I conducted several expert interviews with management staff of Cartuja 93 in the time period of 2010 to 2012 to gain additional information.

¹²² The Cartuja science park has derived its name from the 15th century monastery of La Cartuja de Santa María de las Cuevas (Castells & Hall, 1994).

¹²³ Seville is the largest city in the autonomous community of Andalusia. In 2011, about 1.93 inhabitants were recorded. Overall, Andalusia has approx. 8.4 million inhabitants and is the most populous region (autonomous community) in Spain (National Statistics Institute, 2016).

nies, two departments of the University of Seville, five additional universities and about 20 R&D institutions, as well as several public authorities are located there.¹²⁴ The approximately 210 technology-oriented firms primarily focus on the science park's strategic technology areas: ICT, applied engineering, environment and energy, biotechnology and agro-food, as well as health care technologies.¹²⁵ In total, ca. 16,430 employees work at the STP Cartuja, about 8,360 of them in high-technology firms. In addition, more than 8,000 students study at the science park. In 2015, all resident organizations generated a total turnover of ca. €1.99 billion (Cartuja 93, 2016a; Cartuja, 2016b; Universidad de Sevilla, 2016a).¹²⁶ Overall, the Cartuja science park is the second largest of eleven STPs in Andalusia in terms of employment (Alonso Rodríguez, 2015).¹²⁷

¹²⁴ Figure 22 provides an overview of the scientific institutions located at the Cartuja science park.

¹²⁵ For 2012, Cartuja 93 reported the following structure of high-technology firms in the STP Cartuja: ca. 50% with less than 10 employees (i.e. micro firms), ca. 30% with 10-49 employees (i.e. small firms) and ca. 20% with more than 50 employees (i.e. medium-sized firms) (expert interview with Cartuja 93, 24 September 2012).

¹²⁶ In the time period of 2010-2011, in which the empirical research was conducted, 377 organizations including ca. 180 high-technology companies were located in the STP Cartuja. The total employment was ca. 15,070 persons. About 11,070 persons worked in high-technology companies and scientific institutions. The resident organizations' total turnover, budgets and public funding summed up to about €1,91 billion (Cartuja, 2011a).

¹²⁷ With an employment of about 14,720 persons in 2012, the Andalusia Technology Park in Malaga is the largest STP in Andalusia. Overall, two additional STPs exist in Seville (Aerópolis and Dehesa de Valme), two in Cadiz and one each in Granada, Cordoba, Almeria, Huelva and Jaen (Alonso Rodríguez, 2015).

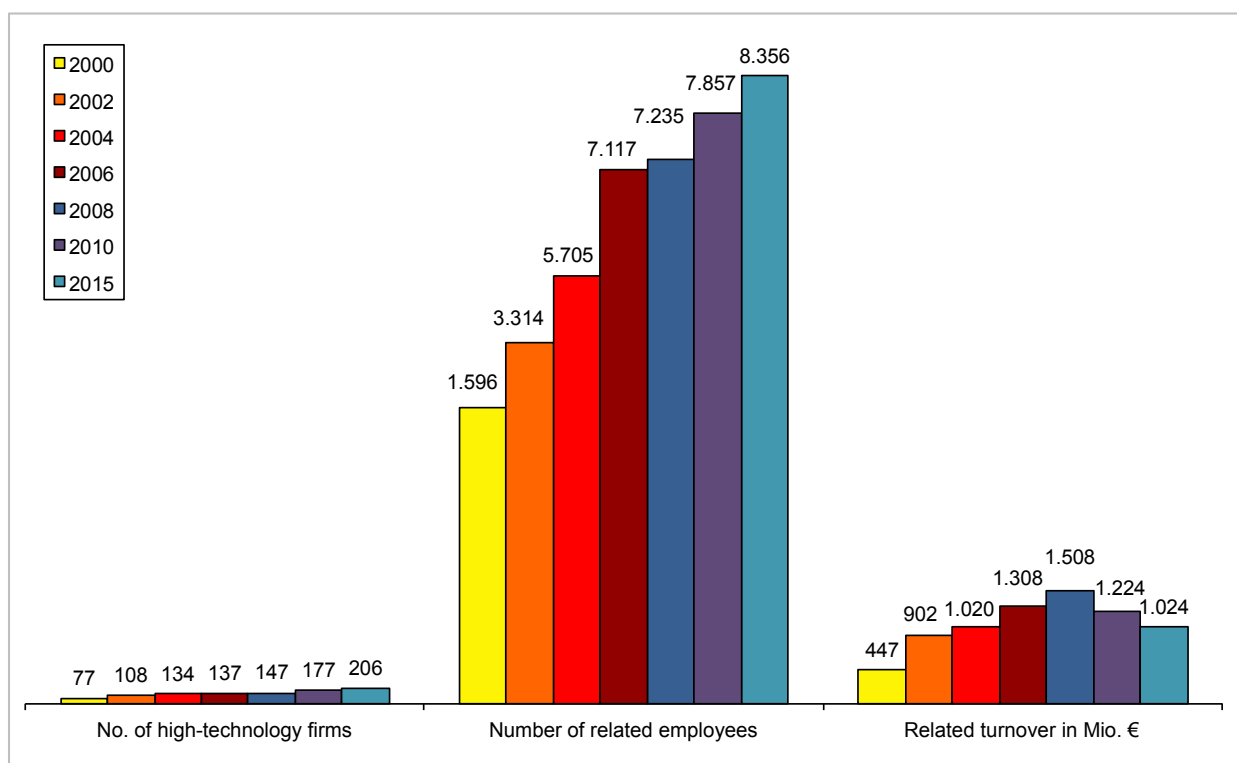
Figure 19: **STP Cartuja today**



Source: Author

In particular since 2000, the high-technology firms at the STP Cartuja have experienced a dynamic growth (see Figure 20). Between 2000 and 2015, the total number of companies increased from 77 to 206. The related turnover grew by more than 230% to ca. €1.05 billion (in 2000: €447 m), while the total employment increased by more than 520% to ca. 8,360 employees (in 2000: 1,600 employees) (Cartuja 93, 2005; Cartuja 93, 2016).

Figure 20: **Development of technology firms in STP Cartuja, 2000-2015**



Sources: Based on Cartuja 93 (2005, 2007, 2009, 2011a, 2016)

Already before the Expo' 92 took place at the site, the regional government of Andalusia had already started the STP Cartuja project. In 1989, a team of international scientists under the leadership of Manuel Castells and Peter Hall (from the University of California-Berkeley) was contracted to design a reuse strategy for the Expo.¹²⁸ The project team underlined the efficient capitalization on the great public investments in the local and regional infrastructure and the sustainable conversion of the Expo site for the anticipated purpose.¹²⁹ In 1991, the STP management company Cartuja 93 was established.¹³⁰ The Cartuja 93 master plan, proposed by PINTA in 1991, included the following elements:

¹²⁸ Also researchers from additional universities (e.g. Autonomous University of Madrid and University of Seville) and technicians of the Andalusian government participated in the project Proyecto de Investigación sobre Nuevas Tecnologías en Andalucía (PINTA) (Castells & Hall, 1994; González Romero, 2002).

¹²⁹ For the Expo' 92, about \$10 billion were invested into infrastructural projects in Seville and Andalusia between 1985 and 1992. Additional public investments were poured into regional education and research programmes (Castells & Hall, 1994). The participating countries and organizations at the Expo were asked to utilize innovative architectural designs for their pavilions in order to allow their reuse (Expert interview with Cartuja 93, 23 November 2010).

¹³⁰ Cartuja 93 S.A. is responsible for the development of the science park's infrastructure, the management of the business centre at the Italian Pavilion and the Marie Curie incubator opened in 2010. Cartuja 93, S.A. is a public-private partnership. The shareholders are the regional government of Andalusia, Agesa, Cajasol, the City of Seville, the Provincial Council of Seville and the University of Seville (Cartuja 93, 2010b).

- Focus on R&D activities in selected areas of technology, which are of strategic importance to the economic development of Andalusia and for international technology transfer, for example, computer software, microelectronics, telecommunications, new materials, biotechnology, renewable energies and environment technologies¹³¹,
- Creation of a scientific-technological milieu through the relocation of the University of Seville's School of Engineering (with ca. 4,000 students) and several public research centres of the National Scientific Research Centre, the Andalusian Research Programme, as well as international research centres¹³²,
- Attraction of corporate R&D facilities of large international technology companies¹³³,
- Development of knowledge linkages between scientific institutions at the Cartuja science park and the regional economy (Castells & Hall, 1994; Peck et al., 1996; González Romero, 2002).

However, in implementing the master plan, the original idea and long-term objective of a scientific-technological milieu was deteriorated in favour of quick increases in local employment and a more profitable real estate development.¹³⁴ As a result, the urban development concept of the STP Cartuja foresees three major elements that characterize the Cartuja science park as a multi-functional site (see Figure 21): 1) Technopolis - the science and technology park with public and private universities and R&D centres, 2) a service hub including public administration, business services and general services¹³⁵, as well as 3) adjacent cultural and recreational activities including a theme park, a park, various museums and sports facilities (Castells & Hall, 1994; Cartuja 93, 1994).

¹³¹ Multiple technology areas were added to the very original concept of the STP's technology profile in response to the intervention of the Andalusian government (Castells & Hall, 1994).

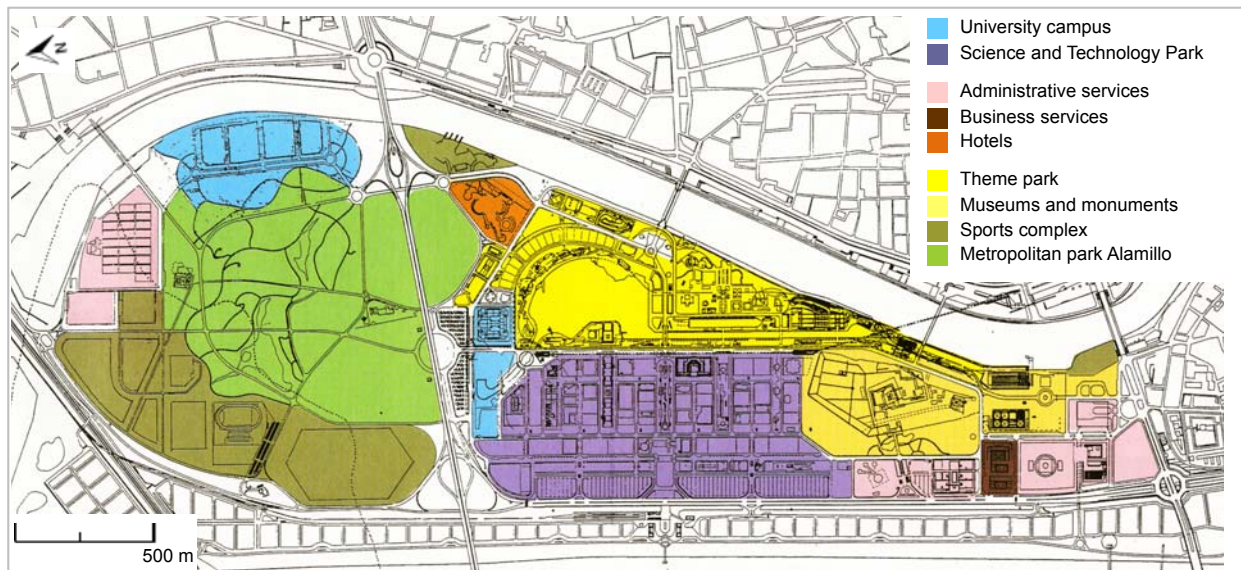
¹³² In order to increase the likelihood of technological and scientific synergies, scientific institutions in selected high-technology areas were targeted as resident organizations, namely software, microelectronics, telecommunication, new materials, biotechnology and renewable energies. As a result, the University of Seville's faculties of humanities were explicitly excluded from the relocation plans, as it was assumed that they have little relation to business and technology (Castells & Hall, 1994).

¹³³ By the end of 1991, about 20 R&D centres of larger Spanish and multinational companies made commitments about locating at the STP Cartuja. It included Philips, Siemens, ONCE and CASA. Specific incentive programmes and low-rent long-term leases promoted the investments (Castells & Hall, 1994, Peck et al., 1996).

¹³⁴ Thereafter, corporate research centres were allowed to include up to 75% of non-R&D related office space. Also, the local political leadership demanded the development of a theme park in order to reduce the increasing local unemployment (Castells & Hall, 1994).

¹³⁵ General services also include multiple restaurants, cafeterias and cafés, which provide opportunities for informal meetings and (un-)intended personal encounters.

Figure 21: **Layout of the Seville-Cartuja science park by distinct functions**



Source: *Cartuja 93 (1994) (modified by author)*

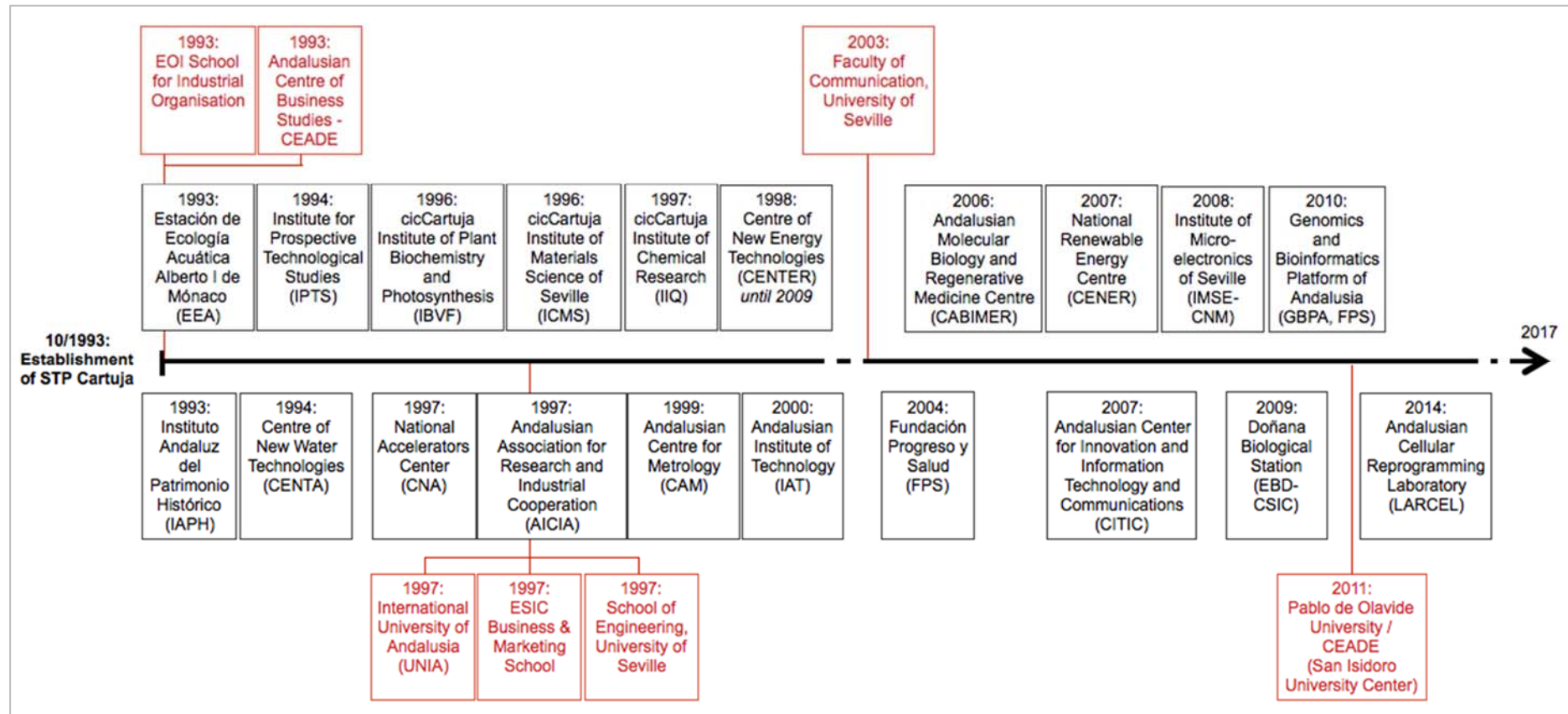
In October 1993, the STP Cartuja was officially inaugurated. The first phase of Cartuja's development, from 1993 to 1996, however, was characterized by moderate development. The STP's strategy to attract large national companies and branch offices of MNEs was not successful. Also, the regional economy did not respond well to the rather internationally oriented investment strategy (González Romero, 2002; Vázquez-Barquero & Carillo, 2004). From 1996 to 1999, the STP's development improved. This was mainly due to a strategy change that placed a stronger focus on local capacities and the promotion of endogenous financial, technology and knowledge resources in a joint effort of public and private regional stakeholders. As a result, regional SMEs became the primary target group for the science park's development, whereas international investments became of secondary interest. Also, public institutions increasingly relocated to the site (Cartuja 93, 2010c). In 1996, STP Cartuja reported the largest number of resident firms of all Spanish science and technology parks. About 110 resident firms, of which the large majority relocated from other regional locations, with ca. 4,300 employees were situated there (Ondategui Rubio, 1997). As a further illustration of the more regionalized focus, the large local companies Inerco, a spin-off of the University of Seville's School of Engineering, and Mac Puar took over two vacant pavillons of the former corporate exhibitors Siemens and Rank Xerox, which left Cartuja in 1999 (Cartuja 93, 2010c). Indeed, in 2002 the largest share of companies had a regional background (ca. 53%) in comparison to national and European companies (ca. 32% and 5%, respectively). However, about 11% of the resident organizations were public entities (González Romero, 2002). Among the latter, several research institutions, universities (e.g. University of Seville's School of Engineering) and regional administrative institutions

relocated at the Cartuja science park in this time period.¹³⁶ Subsequently, multiple additional universities and non-university research institutions followed between 2005 and 2011 in particular.¹³⁷ Figure 22 provides an overview of the dynamic process of university and non-university research institutions taking up residence at the Cartuja science park since 1993.

¹³⁶ It includes the National Accelerators Center (CNA), the Andalusian Association of Research and Industrial Cooperation (AICIA), and the Research Centre of Isla de la Cartuja (cicCartuja), among others (Cartuja 93, 2010c; expert interview with Cartuja 93, 4 April 2011).

¹³⁷ Examples are the Andalusian Molecular Biology and Regenerative Medicine Centre (CABIMER), the National Renewable Energy Centre (CENER), the Andalusian Center for Innovation and Information Technology and Communications (CITIC), and the Institute of Microelectronics of Seville (IMSE) (Cartuja 93, 2008; Cartuja 93, 2009; Cartuja 93, 2010c). Many of them belong to the Spanish National Research Council (CSIC), which is the largest public research institution in Spain. CSIC is part of the Spanish Ministry of Economy and Competitiveness (CSIC, 2016). The San Isidoro University Center of the Pablo de Olavide University and the Andalusian Centre of Business Studies (CEADE) opened in 2011 (Universidad Pablo de Olavide de Sevilla, 2017). Thus, it has not been included in the analysis. The same applies to the Andalusian Cellular Reprogramming Laboratory (LARCEL), which was established in 2014 (Junta de Andalucía, Fundación Progreso y Salud, 2017).

Figure 22: Relocation of scientific institutions at the STP Cartuja since 1993 (non-exhaustive)

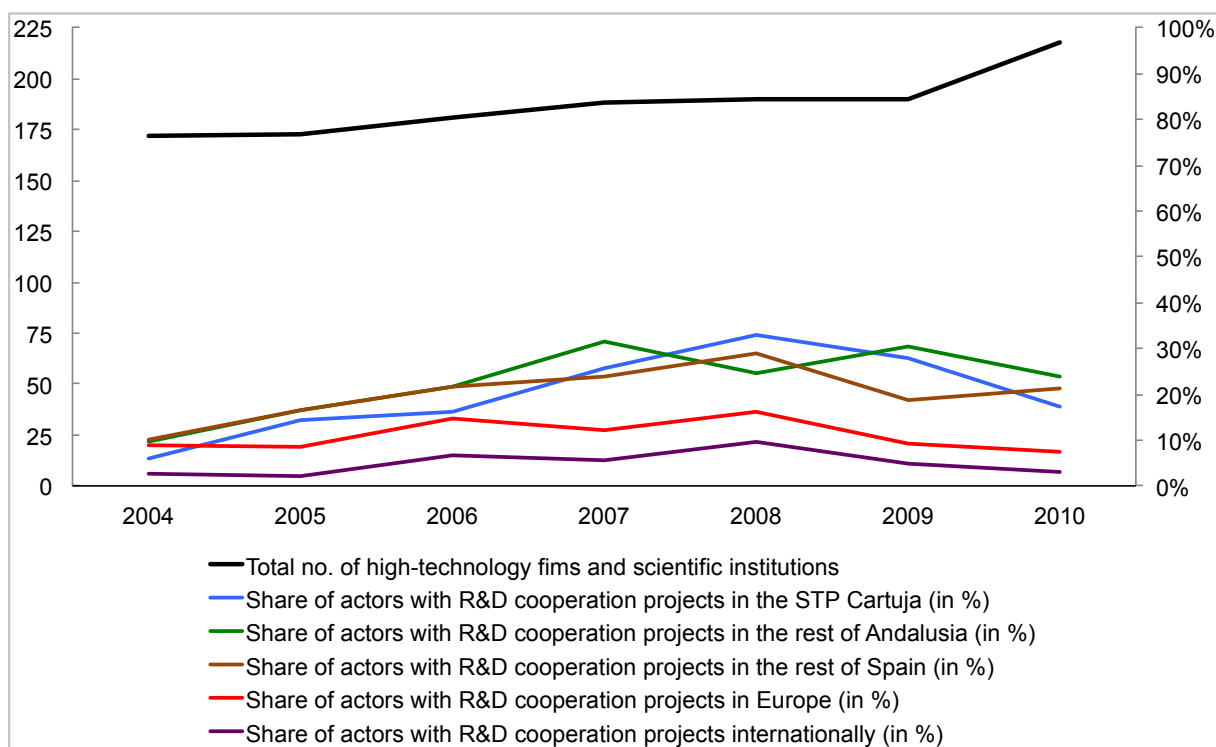


Source: Author (based on Cartuja 93 (2008, 2009, 2010a, 2010c), expert interview with Cartuja 93 (4 April 2011), Fundación Progreso y Salud (2017), Universidad Pablo de Olavide de Sevilla (2017))

Similar to the Adlershof science park, the STP Cartuja is based on the geographical agglomeration of the triple helix, i.e. high-technology companies, complementary scientific institutions and public support institutions. This combination aims to lower regional deficits in industry-academia interaction and to improve the framework conditions to stimulate internationally competitive technological development and to increase the regional economy's innovativeness (González Romero, 2002).

Until now, very little empirical research on localized inter-organizational interaction has been conducted in the STP Cartuja. Being a rare example, González Romero (2002) has identified generally weak interaction among resident organizations at the Cartuja science park. Thereafter, only few examples of strong linkages between co-located firms and academia have been identified. Overall, STP resident companies consider the University of Seville's School of Engineering as the most important local scientific partner. In contrast resident organizations' survey data published in the annual reports of the management company Cartuja 93 indicate a general increase of cooperation in R&D and innovation-related activities for resident high-technology firms and scientific institutions combined since 2004 (see Figure 23).

Figure 23: **R&D cooperation of Cartuja knowledge organizations, 2004-2010**¹³⁸



Source: Author's calculations (based on Cartuja 93 (2005, 2007, 2009, 2011))

Overall, the large majority of cooperation projects in R&D have been realized with partners in the STP as well as on the regional and national scale.¹³⁹ However, only a moderate fraction of ca. 26% to 33% of the high-technology firms and scientific institutions have maintained formal knowledge relations to other co-located actors overall (at a peak from 2007 to 2009). Similar values are observed for R&D cooperation projects on the regional scale in particular and, to a smaller degree, also on the national scale.

¹³⁸ The last comprehensive annual report of Cartuja 93 was published for 2010. Cartuja 93 published only data about the STP's economic performance more recently. However, more recent data in regard to R&D cooperation of Cartuja resident firms and scientific institutions have not been available.

¹³⁹ In Andalusia, in total eleven public and private universities (of which all offer technical and engineering-related study programmes) with ca. 252,000 students and more than 300 R&D and technical training institutions are located. Four universities are located or maintain campuses in Seville. Altogether, ca. 30,000 researchers work in about 2,000 research groups at scientific and higher education institutions in the region. Furthermore, about ten business schools offer study programmes in the region (Agency of Innovation and Development of Andalusia, 2016).

Knowledge network management system at the Seville-Cartuja science park

For the Cartuja science park, a number of different locally provided and locally accessible knowledge network management instruments, which intend to facilitate and support industry-academia knowledge interaction in particular, have been identified. Table 6 provides an overview of the KNM tools detected.¹⁴⁰

Table 6: KNM instruments at the STP Seville-Cartuja

KM instruments	Examples
STP-related knowledge marketing	Cartuja 93, S.A. website, print magazine Cartuja Innova, Scientific and Technological Offer Guide
Local networking events	Cartuja 93 Working Breakfast, COPIT
Locally organized conferences	Foro Innovatec and various other industry scientific conferences and symposia; Regional events occasionally held at STP Cartuja: INNOVÍA, TTAAndalucía
Local and regional intermediaries	STP management: Cartuja 93, S.A.; University TTO: Secretary of Knowledge Transfer and Entrepreneurship of the University of Seville (STCE, formerly OTRI); Regional innovation promoting entities: CITAndalucía (Innovation and Technology Transfer Centre of Andalusia), CTA (Technological Corporation of Andalusia), FIDETIA (Fundación para la Investigación y el Desarrollo de las Tecnologías de la Información en Andalucía), Agency IDEA (Agency of Innovation and Development of Andalusia), Seville Chamber of Industry and Commerce (CIC), RETA (Andalusian Technology Network)
Local formal networks	Círculo de Empresarios de Cartuja

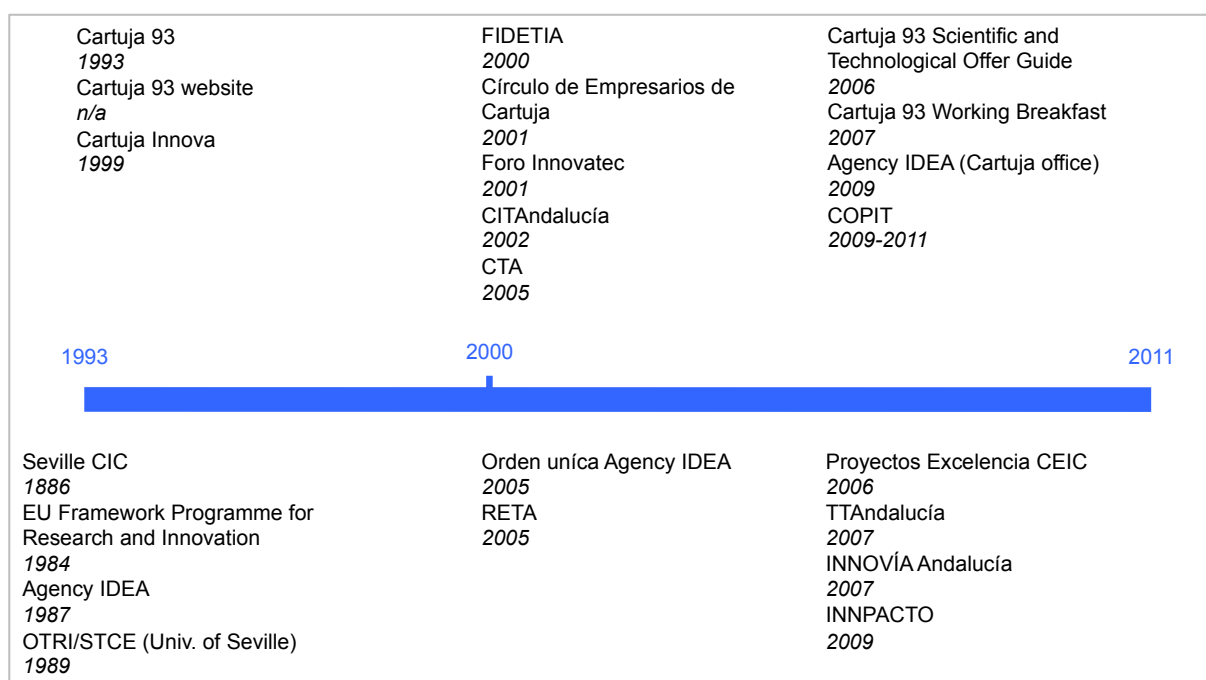
¹⁴⁰ The list of examined KNM measures named for each type is not exhaustive. Generally, the empirical analysis integrates those KNM services and tools that were in place when the empirical analysis was conducted or recently before. A detailed description of the individual KNM organizations and services for the Cartuja case study is outlined in Table A7 in the Appendix.

KM instruments	Examples
Public support programmes for industry-academia R&D projects ¹⁴¹	Orden única Agency IDEA, INNPACTO, Proyectos Excelencia CEIC etc., as well as additional national and European programmes (e.g. EU Framework Programme for Research and Innovation)

Source: Author

The large majority of the specialized KNM instruments and institutions at the STP Cartuja were launched after 2000. This applies to the majority of intermediary organizations and networking events), as well as to the technology network *Círculo de Empresarios de Cartuja*, among others. Others like, for instance, the STP management and the university TTO were active since the early stages of the STP's development (see Figure 24).

Figure 24: **Timeline of KNM instruments at Cartuja science park (non-exhaustive)**



Source: Author (based on expert interview with Cartuja 93 (4 April 2011), Know-Man (2011), European Commission (2014) and websites of named KNM instruments, among others – see Table A7 in the Appendix for details)

Concerning non-locally bound KNM organizations and tools, relevant regional and national conferences, which are also held at the Cartuja science park, as well as regional and national public support schemes for industry-academia R&D projects (e.g. INNPACTO and

¹⁴¹ The Andalusian and Spanish governments, as well as the European Commission typically are in charge of such public R&D programmes. Thus, these support schemes are not confined to Cartuja resident organizations, but rather promote industry-academia R&D projects on the regional, national and European scale in general.

Proyectos Excelencia CEIC) were established in the last ten years, i.e. after 2005. Similarly to the STP Adlershof in Berlin, no empirical analyses have been carried out on the influence of the wide set of KNM instruments at the Seville-Cartuja science park on industry-academia knowledge relations until now.

3.1.3 Summary of a comparative analysis of Adlershof and Cartuja science parks

The two STPs in Berlin and Seville both represent examples of politically initiated and planned re-development projects modelled on the regional triple helix, which aim to evolve to seedbeds of innovation. Overall, both STPs seek to promote the growth of high-technology companies and to facilitate inter-organizational interaction in order to increase the regional economies' competitiveness and innovativeness. Both STPs focus on specific, but also shared areas of technology, for example, ICT, energy and environmental technologies. However, the Berlin-Adlershof and Seville-Cartuja science parks' evolutionary state, size in terms of resident organizations, firms' structure and stakeholder composition are comparable (see Table 7).¹⁴² Also, resembling KNM systems provide a sound basis for a comparative analysis of industry-academia knowledge relations and the impact of specific knowledge network management instruments.

Table 7: Comparative overview of the two science parks' characteristics

	STP Berlin-Adlershof (2015)	STP Seville-Cartuja (2015)
Date of establishment	March 1991	October 1993
History	Location of the GDR Academy of Science, among others	Location of the Expo' 92
Location	Southeast of Berlin city centre (distance ca. 15 km)	Northwest of Seville city centre (distance ca. 3 km)
STP management organization	WISTA-MANAGEMENT GmbH	Cartuja 93, S.A.
Area (in km ²)	4.6 km ²	6.7 km ²

¹⁴² The number of technology firms and institutions of public administration diverge in the two STPs. In the Adlershof science park, there are almost 500 technology firms, in comparison to about 210 technology firms in the STP Cartuja. In contrast, a larger number of public administrative institutions, universities and non-university R&D institutions are agglomerated in the Cartuja science park. Commonly, the large majority of technology firms in both STPs are SMEs.

	STP Berlin-Adlershof (2015)	STP Seville-Cartuja (2015)
Total employment	15,940	16,430
No. of companies (total)	1,013	ca. 340
No. of high-technology companies	495	206
Industry clusters (high-technology)	Optics and photonics, material and micro system technologies, ICT, biotechnology and environment, energy and photovoltaics, analytics	ICT, applied engineering, environment and energy, biotechnology and agro-food, health care technologies
Employment in high technology companies	6,134	8,356
Turnover of resident organizations (total)	€1.89 billion	€1.99 billion
Higher education institutions (HEIs)	1 (six natural sciences' departments of the Humboldt-Universität zu Berlin)	6 (e.g. CEADE, EOI and University of Seville, School of Engineering and Faculty of Communication)
No. of students	6,520	8,130* (*University of Seville, School of Engineering and Faculty of Communication)
Non-university R&D institutions	10	22
Employment in HEIs and R&D institutions	2,735	2,211* (*excluding HEIs)
Budget and third-party funding of HEIs and R&D institutions	€255 m	€202 m (2010)
Specialized entrepreneurship and technology support infrastructure	Two incubators and five technology-specific technology centres	One incubator and one business centre

Sources: Author, WISTA-MANAGEMENT (2016), Cartuja 93 (2011a, 2016a, 2016b), Universidad de Sevilla (2016a)

Nonetheless, some contextual differences need to be emphasized. The Adlershof science park has a long history as a site of academic research, which is still relevant today. Social networks of former scientists of the East German Academy of Science have been found to be important for localized knowledge interaction (Jähnke, 2009; Brühöfener McCourt, 2009). In contrast, the Cartuja science park was developed without any prior background of academic activity. Also, the alignment of the residing universities and university departments, respectively, differs. Whereas the university departments of the HU-Berlin at the Adlershof science park focus on natural sciences, the HEIs at the Cartuja science park primarily comprise universities in technical sciences, communication studies, business management and law studies.¹⁴³

Regarding the knowledge network management systems at both STPs, two minor differences in regard to the quantity of specific KNM instruments should be mentioned. Firstly, numerous local technology networks (Technologiekreis Adlershof, Forum Adlershof and OptecBB) can be identified at the Adlershof science park, whereas only one such formal network (Círculo de Empresarios de Cartuja) is in place at the Cartuja science park. Secondly, the STP Cartuja is characterized by a strong local presence of multiple specialized intermediary organizations (e.g. CITAndalucía, CTA, FIDETIA, Agency IDEA and Cartuja 93) promoting inter-organizational knowledge transfer and innovation activities. In contrast, only three such intermediaries (TSB, Humboldt-Innovation and WISTA-MG) are located in the Adlershof science park.

3.2 Methodology

3.2.1 Methodological framework

The complex, diverse and multi-dimensional character of knowledge relations in general and business-to-science knowledge relations in particular entails certain challenges for analytical studies and requires a fitting model of analysis and assessment (Vedovello, 1997). On the one hand, multiple empirical studies (e.g. Fukugawa, 2006; Löfsten & Lindelöf, 2002) that have focused on match-pair analyses of knowledge flows between on-park and off-park firms have utilized quantitative methods such as microdata analyses and surveys. In these cases, the quantitative research approach has allowed for an accurate

¹⁴³ However, Schartinger et al. (2002) have pointed to similarly strong linkages to industry for university departments in natural sciences, as well as in technical sciences and economics.

comparative analysis of different types of companies and for additional multivariate statistical analyses. The same applies to selected studies (e.g. Fu et al., 2011; Hoekman et al., 2010) that have used survey data and data on co-publications, respectively, to examine the role of proximity in knowledge relations and interactive innovation processes in specific TIS.

On the other hand, the larger share of empirical studies on knowledge relations and knowledge interaction in distinct localities of learning such as STPs and TIS in general have utilized qualitative methods or a mix of different methodologies, most notably, surveys and expert interviews.¹⁴⁴ Such methodology mix has been applied in order to create an in-depth understanding of the underlying mechanisms, for example, in terms of spatial and non-spatial proximity in interactive relations established between firms and co-located scientific actors (e.g. Huber, 2012; Mian et al., 2012). Moreover, qualitative interview data in particular with actors representing different perspectives on the same process may increase the reliability of the data (Ibert & Hautala, 2015).

Accordingly, a methodological mix of complementary empirical approaches is increasingly regarded as essential in academic research, in particular in geography. The implementation of various methodologies enables the control of biased results potentially derived from the use of specific research techniques and also enhances the reliability of the research findings' interpretation and of the evaluation of research hypotheses (Kromrey, 1998; Schätzl, 1994; Wessel, 1996).¹⁴⁵ Overall, the value of the mixed-method approach lies in the ability to provide a more comprehensive and detailed understanding of individual cases (Ibert & Hautala, 2015).

Based on the distinct and complementary strengths of quantitative and qualitative research methods, I used multiple methods and sources for the collection of data (triangulation approach) in my empirical analysis (Mian et al., 2012; Brammer, 2013). In each of the two STPs, starting from secondary data and published material, I collected primary data through standardized interviews and semi-structured expert interviews, which were conducted in-person with numerous STP resident firms in each case. Additional expert interviews included individual STP management staff and researchers.

¹⁴⁴ Additional prominent qualitative research methods applied in the analysis of knowledge relations and knowledge creation include, for example, innovation biographies (Stein, 2014; Ibert & Müller 2015).

¹⁴⁵ A standardized survey allows the identification of trends and specific patterns in large samples. In contrast, qualitative interviews enable the further examination and the collection of more detailed descriptive evidence of these identified trends and patterns. Also, personal interviews are very valuable to ensure the interviewees' comprehension and to obtain a greater accuracy in responses (Smith, 1998).

Chapter 3.1, which has outlined the structure and development process of the two STPs Berlin-Adlershof and Seville-Cartuja, is predominantly based on secondary data and published material. In addition, expert interviews contributed to the description of the STPs' structure and development processes in particular.

Chapter 4 is primarily based on the empirical results derived from the standardized and semi-structured interviews with multiple resident companies in the two science parks.¹⁴⁶

The quantitative research technique, the standardized interview, is based on a standardized questionnaire and a standardized interview procedure (e.g. phrasing and order of questions) (Gläser & Laudel, 2010; Schätzl, 1994). The standardized interviews aimed to generate comparative data of the STP resident companies' interactive relations to scientific institutions. In addition, comparative data were collected regarding the resident firms' assessment of specific internal and external channels, including a variety of KNM instruments, as influencing factors for the successful creation of knowledge relations to scientific institutions and related knowledge sharing processes. In addition, distinct types of firms' egocentric knowledge networks to academia were identified using the multivariate statistical method of a cluster analysis.¹⁴⁷

However, questions regarding the detailed character and the influencing factors of the firms' interactive linkages to scientific institutions, as well as the role of multi-dimensional proximity and proximity-organizing KNM instruments in link creation and knowledge sharing cannot be depicted by quantitative research methods. This is the case especially as there is no universal proximity configuration in knowledge relations (Boschma & Frenken, 2010). Thereafter, in the different contexts of the two STPs and the diverse resident companies, qualitative interviews aimed to explore in detail how the firms' knowledge relations to academia are established and structured, as well as what factors and external framework conditions draw them to form such interactive ties and enable successful knowledge sharing processes. Consequently, the qualitative research method of semi-structured interviews aimed to complement to the previously derived quantitative findings. Also, the qualitative analysis intended to further amplify the identified types of firms' knowledge exchange

¹⁴⁶ Academia-industry knowledge relations and interaction can be measured on two sides: on the side of the firm and on the side of the scientific institution (Schartinger et al., 2002). In this empirical analysis, resident high-technology companies of the Adlershof and Cartuja science parks were selected as the reporting units.

¹⁴⁷ In this thesis, I focus on the analysis of STP resident firms' knowledge exchange behaviour on the egocentric network level, i.e. the specific firm (ego) and its direct linkages. Similar studies have been conducted, for example, by Chan et al. (2010). Generally, there is no general agreement in the literature whether or not the analysis of egocentric networks should also include the linkages among the ego's contacts (Granovetter, 1973). In regard to the whole network, it would require data on the entire set of existing and absent links among the ego's direct ties.

behaviour with academia, which are conveyed from the statistical analysis (cluster analysis).

3.2.2 Empirical research approach

The objective of the empirical research was to pursue an exploratory approach of company case studies in the two STPs. The company case studies aimed to provide qualitative and in-depth descriptive evidence about the firms' knowledge relations to academia, underlying proximity configurations and the influence of KNM systems. Due to the relatively small number of company case studies anticipated, the generalizability of the results is problematic. However, the systematic selection of specific cases aimed to increase the generalizability of the case studies' findings for distinct types of firms (Hautala, 2011b). Therefore, it was aimed to reflect the diverse structure of technology-oriented firms at the two STPs in the company case studies. For this purpose, technology-oriented companies of different sizes (i.e. micro, small and medium-sized firms) and levels of maturity (i.e. start-ups and more mature SMEs) were aimed to be integrated into the empirical analysis.

The empirical data were collected within the EU INTERREG IVC project Knowledge Network Management in Technology Parks (Know-Man).¹⁴⁸ The project was carried out by a project consortium of 15 partners including STPs, universities and research institutions, as well as public administration in six different metropolitan regions in Germany, Spain, Italy, Poland and Slovenia from 2010 to 2012. The Economic Geography section of the Department of Geography of the HU-Berlin was a part of the project consortium.

The combined interviews (i.e. standardized and semi-structured) with resident companies in the Adlershof and Cartuja science parks were realized in the time period from June 2010 to April 2011.

Analogously, I pursued a two-pronged approach to initiate contacts and to select appropriate resident firms at both STPs. Firstly, I used the gatekeeper approach to gain access to STP resident firms (Merkens, 2010). Thus, I asked the two STP management companies WISTA-MG and Cartuja 93 to assist in the process of identifying and contacting suitable resident technology-oriented firms based on the criteria outlined above (quota sample) (Schätzl, 1994). The target group for the personal interviews was the companies' leading

¹⁴⁸ Information about the Know-Man project can still be found at the project's website www.know-man.eu.

management or R&D directors. Through the active involvement of the STP management organizations, higher positive response rates concerning the interview inquiries were anticipated.¹⁴⁹ Secondly, also in order to prevent a biased and homogeneous selection by the STP management companies, I asked successfully interviewed companies to name other high-technology firms on-site that could be willing to participate in the study. In multiple cases, these referrals lead to the participation of additional companies. As a result, interviews with 54 high-technology companies were finally carried out: 26 resident firms at the Adlershof science park and 28 firms at the Cartuja science park. However, two Cartuja resident firms could not be included in the analysis, because the standardized interviews were not completed successfully. Thereafter, an equal number of 26 high-technology companies were examined in each of the two STPs.

After the identification of suitable resident firms, I contacted the firms' management by phone. The firms were introduced to the research project and its objectives. Subsequently, I sent the firms' management the standardized interview questionnaire and the interview topic guide for the semi-structured interview along with a brief description of the research project in order to inform the potential interviewees about the interview's content in advance. In many cases, this was the precondition for the interviewees to participate in the interview.¹⁵⁰ Subsequently, personal meetings were scheduled to conduct the interviews.

At the personal meeting, I introduced the firms' managing directors or senior managers to the interview's context and its two different elements (i.e. standardized interview and semi-structured interview) at first. Subsequently, I went with the interviewee through the standardized questionnaire.¹⁵¹ Afterwards, the semi-structured expert interview was conducted. Overall, going through the standardized questionnaire and conducting the qualitative interview lasted between 30 and 90 minutes. This corresponds to the recommended interview length for personal interviews (Wessel, 1996).

¹⁴⁹ With the active support of the respective STP management organization, the companies' response rate to the author's interview inquiries was predominantly positive. In total, I approached about 35 companies at each STP.

¹⁵⁰ Importantly, the empirical method of combined standardized and semi-structured personal interviews was selected in order to address the firms' management personally and, in turn, generate higher response rates. In particular, Adlershof-based resident companies were subject of numerous empirical studies (i.e. written and email surveys) in the past that resulted in some kind of research fatigue. The management companies of the Adlershof and Cartuja science parks also consistently supported this approach.

¹⁵¹ Due to very limited available time period for the personal meetings, a small number of interviewees completed the standardized questionnaire independently and returned it by email or mail.

The interviews in the Adlershof science park were conducted in German, while those in the STP Cartuja were carried out in Spanish. In several cases, two representatives of a company participated in the interview. Almost all personal meetings were held at the respective company's office.

With the prior permission of the interviewees, the combined interviews were digitally recorded for subsequent transcription. The firms interviewed were made anonymous. I made assurances that the collected data and information were treated with the strictest of confidentiality and no identifying labelling would be attached to any material used in this written report. In order to enable the reader to link cited interview passages to the individual companies each interview was coded.¹⁵²

3.2.3 The quantitative approach: Standardized interviews

By using the quantitative research method of standardized interviews I sought to depict the strength, structure and geography of the STP resident firm's egocentric knowledge networks to scientific institutions and the influence of various firm-specific sources and external channels and platforms related to distinct types of proximity for the creation and realization of such interactive linkages. Thus, the questionnaire utilized for the standardized interview (see Figures A1 and A2 in the Appendix) was based on the research questions laid out in Chapter 2.4.2.¹⁵³ It was structured into three main sections (see Box 6).

Box 6: Thematic blocks of the standardized interview

1. Firm characteristics
2. Strength, forms and geography of knowledge relations to academia
3. Influence of internal and external channels and platforms (KNM instruments) on the creation and realization of knowledge relations to academia

¹⁵² In this code, the letters signify the company related to the specific STP (Berlin-Adlershof or Seville-Cartuja). The number refers to the consecutive number of the interviewed firms at the respective STP (e.g. ADL_01 and CAR_01).

¹⁵³ The questionnaire for the standardized interviews implemented for the EU project Knowledge Network Management in Technology Parks (especially section three) also included additional variables, for example, specific support instruments linked to start-up development, internationalization and talent recruiting. However, the firms' evaluations of these specific variables were not included in the analysis.

The questions of the first section primarily aimed to describe the company's structure and background in more detail, for example, the firm's age, duration of STP residency, total employment, annual turnover, R&D capacities (R&D expenditures and R&D staff), and entrepreneurial background.

The second section sought to determine the general quality of the firms' knowledge relations to academia and the importance of specific channels of local and non-local knowledge relations to academia. As an introduction to this section, the interviewees self-assessed the overall strength of interactive ties to scientific institutions in the last three years.¹⁵⁴ Subsequently, the interviewees were asked to evaluate the importance of specific channels of informal, formal and human resource linkages to co-located scientific institutions (see Table 8).¹⁵⁵

Table 8: Evaluated forms of resident firms' linkages to co-located academia

Categories	Forms of interaction
Informal links	<ul style="list-style-type: none"> • Personal contacts • Access to scientific equipment and infrastructure • Attendance of scientific seminars and courses
Human resources links	<ul style="list-style-type: none"> • Recruiting of academic talent • Personnel exchange (R&D staff) • Formal training for company staff
Formal links	<ul style="list-style-type: none"> • Consulting services • Contract research • Joint research projects • Joint publications • Joint patents • Support in prototype development

Source: Based on Vedovello (1997)

Section 2 closes with the interviewees' evaluation of interactive relations to non-local scientific institutions overall.

¹⁵⁴ An ordinal 6-point Likert scale was applied. It ranged from 1 = no cooperation to 6 = multi-faceted, long-term relations. No multiple responses were allowed. The Likert scale is an empirically proven method for multiple-response scales (Bahrenberg et al., 1999).

¹⁵⁵ Each variable regarding local and non-local knowledge linkages to academia was assessed based on a 5-point Likert scale with no multiple responses allowed. The Likert scale ranged from 1 = not important to 5 = very important. Additionally, if a specific channel of interaction was not applicable to the interviewed company, the alternative response option not applicable (N/A) (outside the Likert scale) could be selected.

Finally, the goal of section 3 was to identify proximity-related influencing factors responsible for the successful development and realization of the resident firms' knowledge relations to scientific institutions. On the one hand, it is differentiated in two firm-specific channels; personal networks and direct requests by scientific institutions. On the other hand, the relevance of transfer channels and platforms was evaluated.¹⁵⁶ In this regard, the influence of eight specific KNM tools, which correspond to the three main categories of knowledge management instruments (see Chapter 2.3.1), was examined (see Table 9).¹⁵⁷

Table 9: Evaluated KNM instruments

Categories of knowledge management instruments	KNM instruments
Information management	STP-related knowledge marketing
People management / social systems	Local networking events
	Locally organized conferences
External structures	Local and regional intermediaries: - STP management organization, - University TTO, - Regional innovation promoting organizations.
	Local technology networks
	Publicly subsidized programmes for industry-academia R&D projects

Source: Author

The majority of questions in the standardized interview were closed-ended questions with multiple-choice response categories. Few open-ended questions were integrated, for example, regarding the company's date of establishment and date of location at the STP.¹⁵⁸ The standardized interview's questionnaire utilized common definitions (e.g. SMEs) and classifications (e.g. employment, annual turnover and R&D expenditures). Apart from section 3, the questionnaire was identical in both STPs.¹⁵⁹

¹⁵⁶ Analogue to section 2, a 5-point Likert scale with no multiple responses allowed was applied.

¹⁵⁷ Due to the specific contexts of the Adlershof and Cartuja science parks, section 3 of the questionnaire was designed individually naming the specific KNM instruments and institutions relevant for the respective STP.

¹⁵⁸ A comprehensive overview of the variables examined in the standardized interview, as well as related response options and measurements is provided in Table A3 in the Appendix.

¹⁵⁹ Overall, the standardized interview's questionnaire was designed to be self-explanatory and universally comprehensible. A German version and a Spanish version were developed for the standardized interviews at the Adlershof and Cartuja science parks, respectively.

3.2.4 The qualitative approach: Semi-structured expert interviews

The qualitative research method looked to gain an in-depth understanding of the function and impact of spatial and relational dimensions of proximity in the STP resident firms' knowledge linkages to scientific institutions. In relation to the research questions about the distinct underlying factors in actors' knowledge relations, qualitative research methods are found to be especially applicable as they feature the capability to provide evidence about the specific individual contexts and implicit structures relevant in social relations (Meuser & Nagel, 1991). In other words, qualitative methods such as interviews can explore tacit natures of knowledge more effectively than quantitative approaches (Ibert & Hautala, 2015). Furthermore, the flexibility and openness linked to qualitative research methods also enable the validation and questioning of (previously formed) theoretical concepts and previously derived quantitative findings, as well as the incorporation of relevant new aspects (Lamneck, 2005).

The implemented qualitative interviews enabled the empirical exploration of how the firms' egocentric knowledge networks to academia are established, how knowledge sharing processes are implemented and what framework conditions are critical to form and realize successful knowledge relations. In this respect, the specific functions of spatial and non-spatial proximity as necessary, critical and auxiliary criteria in industry-academia knowledge interaction were explored. In addition, the relevance of specific KNM instruments, characterized by varying proximity-organizing mechanisms in the facilitation of industry-academia knowledge ties were investigated in more detail. These aspects could not be detected in the quantitative analysis. Finally, more comprehensive information about the character of resident firms' linkages to academia on different geographical scales could be generated.

Within the range of different qualitative research methods, semi-structured expert interviews based on an interview topic guide, which are referred to the category of semi-standardized research methods, were selected as the appropriate technique (Kromrey, 1998; Schätzl, 1994). On the one hand, semi-structured interviews served to ensure a certain comparability between the different company case studies in the two STPs. On the other hand, a certain flexibility regarding the order of questions and topics order was helpful to react individually to firm-related contexts and specific interview situations. Overall, the semi-structured interviews primarily aimed to amplify the quantitative findings and to explore the firm-specific contexts (Meuser & Nagel, 1991; Schätzl, 1994).

In general, expert interviews aim to analyze the structure and relations of the interviewees' knowledge and behaviour (Meuser & Nagel, 1991). They are typically characterized by a standard interview situation, which usually is asymmetrical as the interviewer consults the expert in to order to obtain information from the expert and gain insight into the expert's assessment of specific issues (Kromrey, 1998). Therefore, prior to the interviews, I tried to gain sufficient expertise to enable a sound comprehension of the interviewee's statements, as well as to allow the development of a substantive interview (Pfadenhauer, 2009). This included the revision of the theoretical background of the research project (see Chapter 2), the science parks' development processes, strategic focus, compositions of resident organizations and relevant KNM instruments (see Chapter 3.1), as well as the profile of the companies interviewed.

The design of interview topic guide was based on the standardized interview's questionnaire (see Box 7). It comprised several central questions (open questions), which are linked to the research questions. As mentioned, the topic guide enabled a certain flexibility to allow additional questions or arguments relevant to the overall topic (see Figures A1 and A2 in the Appendix).

Box 7: Central issues of the semi-structured expert interview

- | |
|--|
| <ol style="list-style-type: none">1. Introduction to the company2. Knowledge relations to scientific institutions and influencing factors3. Relevance and effects of KNM instruments on interactive ties to academia |
|--|

As an introduction to the interview, I asked the interviewee to briefly outline the company's history, products, markets and relocation to the STP. Also, the professional background of the interviewee was discussed. These general questions at the beginning aimed to create a trustful and open interview environment between the interviewees and the interviewer.

As the first main topic, the character and content of the firm's specific knowledge relations to scientific institutions in the STP and external to the STP was reviewed. In this respect, the interviewee was asked to name local and non-local academic cooperation partners. Importantly, the origin and evolution of these relations, as well as the underlying criteria and factors responsible for the formation of the interactive linkages and the successful realization of knowledge interaction were discussed. Also, questions regarding existing obstacles and necessary improvements in order to enable productive knowledge relations to academia were raised.

The influence of specific KNM instruments on the successful creation and realization of knowledge linkages to academia was the second main topic of the qualitative interview. Based on the quantitative evaluation of the different KNM tools in the standardized interview beforehand, the success criteria and deficits related to the specific support instruments and entities examined were placed at the centre of the interview. Finally, the interviewee was asked to elaborate on the needs and demands for a more effective KNM system.

A pre-test of the combined standardized interview and semi-structured expert interview in order to assess and validate the research design's consistency and comprehensibility was conducted with four resident companies of the Adlershof science park in June and July 2010. The pre-test confirmed the combined interviews' conceptual design (Wessel, 1996).¹⁶⁰

3.2.5 The data set

In total, 52 combined interviews with STP resident companies in the Adlershof and Cartuja science parks were successfully completed. As shown in Table 10, different types of companies (distinguished by different sizes and stages of development) are represented in each STP-related sample.

Table 10: Interviewed high-technology firms at the two science parks (n=52)

	STP Berlin-Adlershof	STP Seville-Cartuja
<i>by size of employment</i> ¹⁶¹		
Micro firms	12	12
Small firms	12	8
Medium-sized firms	2	6
<i>by stage of development</i>		
Start-ups (≤ 3 years) ¹⁶²	5	13

¹⁶⁰ The four interviews of the pre-test were also included in the analysis.

¹⁶¹ The classification of firms by size of employment is based on the SME definition of the European Commission: micro firms (<10 employees), small firms (10-49 employees) and medium-sized firms (50-250 employees) (European Commission, 2016).

¹⁶² Aldrich et al. (1987) have considered the stage from one to three years as the emergence stage in a business' life cycle. Therefore, start-up firms are defined as companies with an age of up to three years.

	STP Berlin-Adlershof	STP Seville-Cartuja
Mature SMEs (>3 years)	21	13
Total	26	26

Source: Author

3.2.6 The data analysis

Quantitative analysis

I inserted and evaluated the data gleaned from the standardized interviews with Microsoft Excel and the statistical software programme SPSS 23.0. The data set compounds nominal, categorical and ordinal data. The answers of some open-ended questions were subsequently categorized into specific categories by the author (e.g. firm's date of establishment and total workforce). Ordinal data are primarily derived from the questions evaluating different forms of interaction with scientific institutions, as well as firm-specific and external channels and settings facilitating such interactive ties, for which a Likert scale was applied.

Individual item non-responses occurred as some interviewees refused to provide information about the firms' turnover and R&D expenditures.¹⁶³ Item non-responses are a common problem in empirical research. However, it is assumed that the specific data exists. In these cases, the EM (Expectation-Maximization) algorithm imputation method was utilized.¹⁶⁴ It replaces the missing values based on the data within the dataset instead of adding additional information (Graham, 2009; Brosius, 2013). Overall, I evaluated the collected quantitative data using frequency counts, crosstabulations, contingency analyses and a cluster analysis.

¹⁶³ One Adlershof-based company and two firms at the STP Cartuja did not provide any information about their turnover in 2009. Additionally, four firms at the STP Cartuja did not disclose any information about R&D expenditures (in % of the annual turnover). Little's MCAR test confirmed that the data are completely missing at random.

¹⁶⁴ The imputed missing values were necessary for the contingency analysis, as a subsequent step to the cluster analysis, in particular.

Frequency counts and crosstabulations

Counts of absolute and relative frequencies are methods of descriptive statistics. Primarily, frequency counts were used to differentiate the companies based on specific firm characteristics recorded in the questionnaire's section 1, for example, by the duration of STP residency and various entrepreneurial backgrounds (e.g. academic spin-offs and independently established firms).

I applied crosstabulations to detect and validate causal connections of certain firm-specific characteristics, for example, companies' age and the micro location at the STP (e.g. incubators) or the firms' entrepreneurial background and the size of employment. Furthermore, the relation of specific company characteristics and the firms' assessment of interactive ties to academia were identified (Bahrenberg et al., 1999).

Hierarchical cluster analysis

In this quantitative analysis, it was aimed to identify specific types of firms' knowledge networks with scientific institutions in terms of the linkages' strength, structure and geography. For this purpose, 14 different variables evaluated by the interviewees in the standardized interviews were applied (see Chapter 3.2.3):

- One variable measuring the general level of interaction with scientific institutions in the last three years,
- Three variables measuring the importance of informal modes of interaction with co-located scientific institutions (e.g. personal contacts and use of scientific infrastructure),
- Three variables measuring the importance of HR links with co-located scientific institutions (e.g. recruiting of academic talent and staff exchange),
- Six variables measuring the importance of formal modes of cooperation with co-located scientific institutions (e.g. contract research and joint R&D projects),
- One variable measuring the importance of interaction with non-local scientific institutions overall.

The cluster analysis belongs to the explorative methods of multivariate statistical analysis. It aims to detect specific commonalities between objects. Therefore, it groups objects of a heterogeneous sample to different groups in a way that objects in the same group are characterized by a high degree of homogeneity, while the different groups are

characterized by a high degree of heterogeneity among them (Backhaus et al., 2008). In this case, I applied the hierarchical clustering method by Ward. This method pursues the creation of approximately even groups in terms of the number of objects, which are characterized by a maximum homogeneity in the same group and a maximum heterogeneity among the different groups. In fact, the Ward method is characterized by a grouping process that reduces the internal heterogeneity incrementally. It is widely-used and considered as rather conservative. For the successful and comprehensible implementation of the cluster analysis, the data should fulfill the following criteria: 1) variables measured in metric scales and 2) no correlation between the different indicators (Backhaus et al., 2008; Bahrenberg et al., 2008).

However, weaknesses in the empirical research design resulted in severe constraints for the projected cluster analysis:

- In the standardized interviews, multiple firms did not evaluate several variables related to specific forms of interaction with academia by using the 5-point Likert scale. Instead, the interviewees used the alternative response option N/A to indicate that this specific form of interaction is not applicable to the company. However, the nominal N/A response option cannot be considered as part of the ordinal 5-point Likert scale.¹⁶⁵
- Overall, 31 out of 52 standardized interviews (60%) include one or more N/A items.¹⁶⁶ As a result, only 21 companies (40%) provided valid ordinal data for the entire set of 14 variables relevant to the projected cluster analysis.
- Interpreting the N/A items as missing values and, consequently, applying a listwise or pairwise deletion would have minimized the total sample significantly (Backhaus et al., 2008). Also, due to the large number of N/A items, the application of an imputation method (e.g. mean imputation and Expectation-Maximization algorithm imputation) most likely would have lead to biased estimates (Brosius, 2013).

Therefore, I developed an alternative, but cognate approach to deal with the large number of obtained N/A items in this data set and to generate a sufficient number of valid interview

¹⁶⁵ Expert interview with Josef Nipper, University of Cologne (6 September 2016).

¹⁶⁶ N/A items primarily occurred for variables measuring specific forms of localized formal and human resource links to scientific institutions. The highest numbers of N/A items were on joint patents (n= 24), joint publications (n= 23), exchange of staff (n=23), contract research (n= 22), joint prototype development (n=19) and formalized training of company staff (n=18).

data to enable a meaningful cluster analysis. This approach applied is very similar to the construction of indices:¹⁶⁷

- Firstly, responding to the first criteria of the hierarchical cluster analysis (Ward) and to determine a ranking of the firms' evaluations, the ordinal-scaled variables measured by Likert scales were treated as equidistant and, thus, quasi-metric (Bortz, 1999).¹⁶⁸
- Secondly, the 14 variables measuring different forms of business-to-science interaction were aggregated to five overall categories: 1) general intensity of interaction (one item), 2) localized informal interaction (three items), 3) localized human resource-related interaction (three items), 4) localized formal cooperation (five items), and 5) non-local interaction overall (one item). Subsequently, the mean of the five created categories was calculated using only the valid items for each category. N/A items were omitted. As a result, new index-like values for the five categories were created for the 52 companies (Laatz, 1993).¹⁶⁹ For example, if an interviewee had provided valid data for two out of the three items aggregated in the category of localized informal interaction, the mean of the two valid items was applied in the statistical analysis.
- Thirdly, only those companies that had provided valid data for all five compiled categories were incorporated into further multivariate statistical analysis. As a result, complete data sets for 39 companies were identified.
- Fourthly, in order to fulfil the second criteria of the cluster analysis, a principal component analysis (PCA) was conducted.¹⁷⁰ As a result of the PCA, three principal components were retained.¹⁷¹ They explain the following categories of variables: 1) overall level of interaction with academia in the recent past; 2) informal, talent related and formal linkages to co-located scientific institutions and 3) interaction with non-local

¹⁶⁷ The alternative approach was reaffirmed with Josef Nipper, University of Cologne (expert interview, 6 September 2016).

¹⁶⁸ In the standardized interviews, the answer categories of the applied Likert scales were described verbally and numerically in order to ensure equidistance.

¹⁶⁹ The construction of indices is either based on theoretical considerations or mathematical formulas. In this case, additive indices were developed which are based on the mean of the summed valid items (equal weights) for each category of variables (Laatz, 1993).

¹⁷⁰ This step was necessary as specific categories of variables are strongly correlated (e.g. categories 1 and 5, as well as the categories 2, 3 and 4). In order to avoid biased results of the cluster analysis, a PCA was conducted. Generally, the PCA aims to reduce and group a broad set of items, respectively, to generate components that reproduce the complexity of selected variables comprehensively (Bahrenberg et al., 2008; Backhaus et al., 2008).

¹⁷¹ Based on the total number of five categories of variables, the PCA (Varimax rotation) extracted five principal components. However, for three out of the five principal components the eigenvalue was less than 1 (component 1: 2.403; component 2: 1.585; component 3: 0.515; component 4: 0.281; and component 5: 0.217). Instead of the commonly used Kaiser criterion (eigenvalue > 1), I utilized the alternative method of the Scree plot to determine the number of extracted principal components (Backhaus et al., 2008).

academia overall.¹⁷² The three principal components derived were orthogonal and uncorrelated (Bahrenberg et al., 2008; Backhaus et al., 2008). The result of the PCA was satisfactory in statistical terms since the three principal components are able to explain over 90% of the variance of the original sample.

- Fifthly, based on the three principal components, the hierarchical cluster analysis (Ward) identified two groups of firms, which are distinguished by specific knowledge exchange behaviours with scientific institutions in terms of strength, structure and geography of knowledge relations.¹⁷³ A discriminant analysis was applied to verify and optimize the configuration of the identified groups detected in the cluster analysis (Bahrenberg et al., 2008; Backhaus et al. 2008).¹⁷⁴
- Ultimately, the N/A responses were not considered as non-responses, as they contain actual information and reflect the interviewees' real opinions. Thus, firms with invalid data for one or more of the five compiled categories of variables, which were omitted from multivariate statistical analysis, were considered as a separated group (n=13) that is constituted by so-called un-scalable companies. This group was regarded as a statistical entity of its own and was subject of further analysis, too.

The two clusters identified in the alternative approach of the cluster analysis and the additional group of unscalable companies were applied to further descriptive statistical analysis (e.g. cross-tabulations, contingency analysis).

Contingency analysis

Similarly to crosstabulations, the contingency analysis is applied to detect certain causal connections. Using contingency tables it is examined whether observed frequencies of variables in groups of objects differ statistically significant from expected frequencies (Backhaus et al., 2008).¹⁷⁵ In this case, the contingency analysis was applied to test

¹⁷² The factor loadings are the correlation coefficients between the variables and factors. In this PCA, all five created categories of variables are clearly linked to one specific principal component only (German: Einfachstruktur) (Backhaus et al., 2008).

¹⁷³ There is not any objective method to determine the optimal number of groups. The number of final clusters has to be carefully selected. An increase or reduction of identified cluster groups affects the groups' internal heterogeneity and homogeneity, respectively (Hair et al., 2006).

¹⁷⁴ The discriminant analysis resulted in an optimized result of the cluster analysis. Two companies were reallocated between the two groups (cluster 1: n=18; cluster 2: n=21).

¹⁷⁵ The contingency analysis enables the consideration of different scales of variables as any kind of variable can be transformed to the nominal scale. However, it has to be acknowledged that such transformation is

whether the specific groups of firms identified in the cluster analysis show equal assessments of internal and external channels and settings (including a broad set of distinct KNM instruments) determining the successful development and realization of knowledge relations to scientific institutions.

Qualitative analysis

The qualitative content analysis is defined as “a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (Hsieh & Shannon: 1278). Here, I used the qualitative content analysis to describe, to interpret and to evaluate the content of the semi-standardized interviews with the 52 STP resident firms. Initially, I reviewed the recorded interviews. Afterwards, relevant parts of the interviews were transcribed, word-for-word. For the purpose of this thesis, cited extracts from the transcribed interviews in German and Spanish were translated into English. Subsequently, I evaluated the interview data using a systematic classification system, which was developed based on the theoretical concepts and the reprocessing of the research problem. The individual categories each compound multiple related key words that describe and identify certain themes and patterns. Based on the key words, information relevant to the research questions were extracted and analysed. Furthermore, additional new categories with identified related key terms were added. As a result, the category system’s openness enabled the flexible refinement and adjustment of specific categories, as well as the supplementation of relevant new information and findings (Kromrey, 1998; Gläser & Laudel, 2010). The qualitative data analysis was performed using the MAXQDA software.

In particular, I analysed the interviewees’ responses related to the two subjects that were at the centre of semi-standardized expert interviews: the firm’s knowledge relations to academia and associated influencing factors, but also obstacles of link creation and knowledge interaction, and 2) the functionality and success factors of specific KNM instruments in facilitating such interactive linkages, as well as observed deficits in the case of ineffective KNM tools. Thus, I utilized the qualitative data to triangulate with the quantitative data that was obtained from the assessments given by firms on their knowledge relations to aca-

related to a loss of information. Furthermore, the chi-square test of homogeneity gives an indication whether specific characteristics are equally distributed in different groups of actors. The phi coefficient and contingency coefficient measure the degree of interaction between the relevant variables. A phi coefficient higher than 0.3 indicates a strong interaction of the relevant variables. Moreover, the contingency coefficient is based on the phi coefficient. Its value can range from 0 to 1 (Backhaus et al., 2008).

demia, as well as of the internal and external channels and settings responsible for the successful development and realization of such interactive ties. It aimed to strengthen the validity of the quantitative findings' evaluation and interpretation and to gain an in-depth understanding of the underlying mechanisms. Moreover, I selected specific interview statements to illustrate the structure and geography of a company's egocentric knowledge network to academia, as well as the underlying factors and criteria related to specific proximity configurations that contribute to successful link creation and knowledge interaction. Also, I used selected interview statements to demonstrate the organization of multi-faceted or individual proximity through specific KNM instruments.

3.2.7 Limitations of the empirical approach

In addition to the already mentioned deficits in the design of the Likert scale in the standardized interview's questionnaire impeding the application of a cluster analysis (see previous chapter), the implemented empirical approach entails various additional limitations, which have to be considered in the following analysis and in the development of conclusions.

In particular, the relatively small number of 39 companies, which were finally integrated in the cluster analysis, may cause some criticism and doubts about the informative and explanatory value of the analysis. However, other scholars (e.g. Kulke, 1986; Bahrenberg et al., 2008; Chan et al., 2010) have also conducted cluster analyses using samples of rather small sizes.¹⁷⁶ Moreover, the in-depth expert interviews in particular enhance the informative and explanatory value of the empirical research to a great extent.

Furthermore, the examined companies were not selected on a random basis. Instead, the STP management companies of the Adlershof and Cartuja science parks actively supported in the selection of suitable companies, which may have caused bias. Moreover, it can be assumed that the interviewed companies are more open to interaction and cooperation in general. This approach was primarily linked to the research project's integration into the Know-Man project. Anticipated fast and high response rates of STP resident firms due to the assistance of the STP management firms aimed to respond to the

¹⁷⁶ For example, Kulke (1986) has considered inter-firm interdependencies of 86 companies in four different regions. Chan et al. (2010) have conducted a cluster analysis of 25 STP resident firms. Bahrenberg et al. (2008) have grouped 65 districts in four clusters, while Schäkel (1996) has shown that a cluster analysis of 77 agricultural firms with derived groups of less than 20 objects also is valid.

need for a quick implementation and analysis of the empirical research required by the Know-Man project's time plan. However, referrals by previously interviewed firms were used as an additional approach for identifying suitable resident firms to prevent biased results. Also, the systematic selection of resident companies based on specific criteria (i.e. age and size of employment) aimed to include diverse technology-oriented STP resident companies in the analysis.

Moreover, the empirical research is based on subjective assessments of the interviewees. Therefore, it cannot be precluded that the assessments reflect the actual situation and circumstances (e.g. based on false statements and insufficient knowledge). In particular, as the qualitative interviews aimed to tap into tacit knowledge and to add more in-depth knowledge, the interviewees' opinions and assessments on knowledge relations and relationship building processes may be prone to the risks of ex-post rationalization, selective memory and time-bound interpretations of the past (Ibert & Hautala, 2015).

In regard to additional strands of research on the proximity framework in knowledge relations, this analysis does not aim to determine the effect of specific natures of proximity on the examined firms' business and innovative performances. Also, I do not aim to identify the optimal level of proximity (in whatever dimension and combination) for interactive learning and innovation, as pursued, for example, by Cassi & Plunket (2014). Furthermore, this analysis is predominantly based on data at a specific point in time. Dynamic changes of proximity in knowledge relations, for example, studied by Balland et al. (2015), are not examined explicitly. However, individual interview statements may provide indications on learning and the dynamic development of specific types of proximity in the firms' knowledge relations to academia.

4. Empirical analysis: Proximity configurations in knowledge relations of Adlershof and Cartuja resident firms to academia

Chapter 4 aims to provide the answers to the five research questions outlined in Chapter 2.4.2 of this thesis. At first, I provide an overview of the characteristics of the examined high-technology firms at the Berlin-Adlershof and Seville-Cartuja science parks (see Chapter 4.1).

For the resident companies of the two STPs, I then examine the strength, structure and geography of their interactive relationships to scientific institutions (see Chapter 4.2).

In Chapter 4.3, I develop an overall typology of knowledge seeking STP resident companies based on the specific patterns of knowledge exchange behaviour with scientific institutions. Subsequently, Chapter 4.4 analyses the influence of firm-specific and external channels and settings including knowledge network management instruments as responsible determinants explaining different qualities and patterns of resident businesses' knowledge relations to academia.

Based on the qualitative analysis, Chapter 4.5 explores the proximity configurations that matter in STP resident firms' local and extra-local knowledge relations to academia. This section also investigates the interplay and trade-offs of specific spatial and non-spatial proximities.

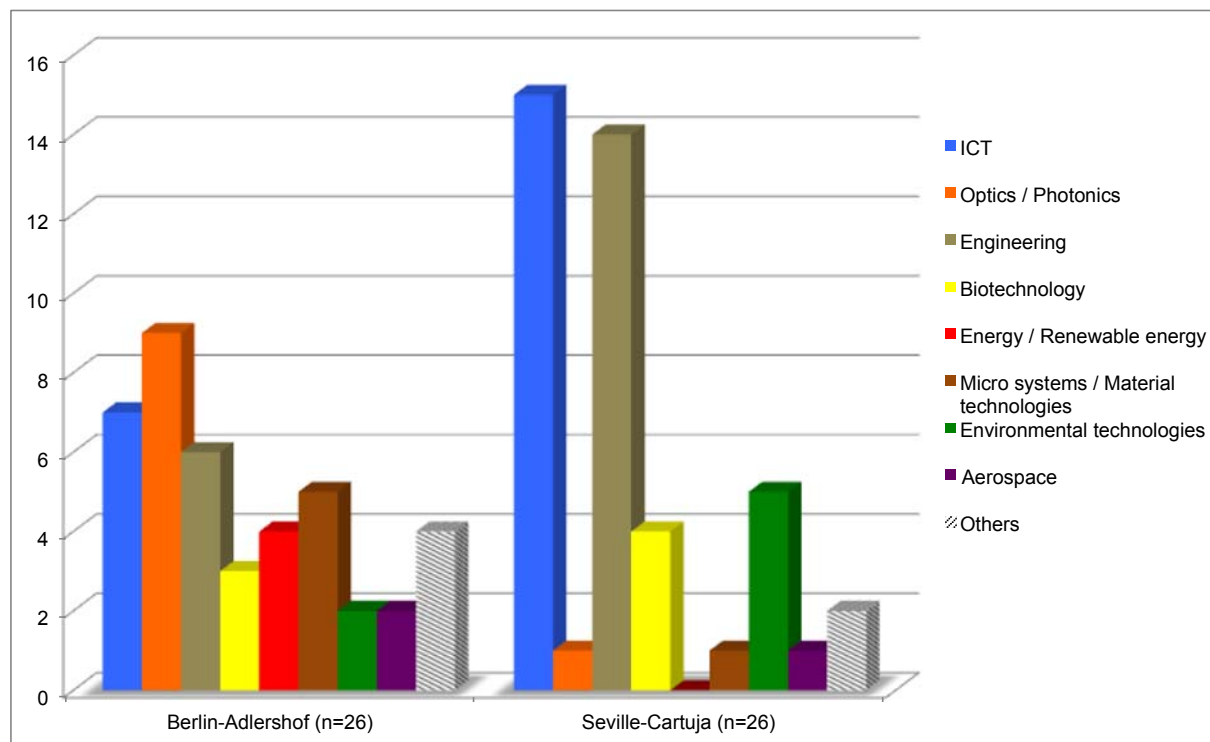
Ultimately, I seek to assess the underlying mechanisms of knowledge network management instruments in regard to the systematic organization of specific natures of proximities that are identified as necessary, critical or auxiliary criteria for successful link creation and productive knowledge interaction (see Chapter 4.6).

4.1 Overview: Technology-based firms at Adlershof and Cartuja science parks

The empirical analysis examines a total of 52 firms located in the two science parks in Berlin (n=26) and Seville (n=26). Overall, all interviewed companies are classified as technology-oriented companies fulfilling the first selection criteria (see Chapter 3.2.2). In the STP

Adlershof sample, the majority of businesses work in optical technologies, ICT, engineering, as well as micro systems and material technologies (see Figure 25).¹⁷⁷

Figure 25: **Companies by industry (multiple entries allowed)**



Source: Author

In contrast to this rather diverse set of technology companies, the sample from the STP Cartuja primarily includes firms in ICT and engineering. Moreover, individual companies focus on biotechnology and environmental technologies. Overall, the high-technology industries, in which the interviewed companies operate, correspond to the defined key technology areas in the two science parks.¹⁷⁸ Businesses that focus on ICT, engineering and biotechnology are included in both STPs' samples.¹⁷⁹

¹⁷⁷ In many cases, interviewed firms indicated multiple related technology areas and industries, respectively, in which they operate in, for example, ICT and engineering.

¹⁷⁸ The technology-oriented firms at the Adlershof science park operate in the following areas of technology: ICT (35%), optics and photonics (25%), biotechnology and environment (19%), micro systems and material technologies (12%), as well as energy (8%) (WISTA-MANAGEMENT, 2016b). In the STP Cartuja, technology-oriented firms operate in the following areas of technology: ICT (39%), engineering (30%), health care technologies (9%), energy (8%), biotechnology / agro-food (7%) and environment (7%) (Cartuja 93, 2011a).

¹⁷⁹ Different knowledge bases characterize the firms examined in both STPs: analytical (natural science based knowledge) and synthetic (engineering science based knowledge). As mentioned earlier, companies operating in analytical knowledge tend to be less sensitive to co-location in knowledge relations, whereas firms operating in synthetic knowledge place a higher emphasis on geographical proximity (Martin & Moodysson, 2013; Ibert & Hautala, 2015). However, this strand of the research is not addressed in this thesis.

Furthermore, the analysis also aimed to include specific types of technology-oriented firms, distinguished by different levels of maturity and the size of the firms, at the two science parks. Thereafter, mature companies (81%) comprise the largest share of the interviewed businesses at the Adlershof science park in Berlin (see Table 11). Additionally, five start-up companies are included. In contrast, start-up firms (50%) and mature firms (50%) are equally represented in the Cartuja-based sample.¹⁸⁰

Table 11: STP resident companies by level of maturity

	STP Adlershof		STP Cartuja		Total	
	absolute	in %	absolute	in %	absolute	in %
Start-ups (≤ 3 years)	5	19.2	13	50.0	18	34.6
Mature firms (> 3 years)	21	80.8	13	50.0	34	65.4
Total	26	100	26	100	52	100

Source: Author

In addition, STP resident companies of different size (in terms of employment) are included, of which the large majority are characterized as micro businesses and small firms overall (see Table 12).¹⁸¹

Table 12: Companies by size of employment

	STP Adlershof		STP Cartuja		Total	
	absolute	in %	absolute	in %	absolute	in %
Micro firms	12	46.2	12	46.2	24	46.2
Small firms	12	46.2	8	30.8	20	38.5
Medium-sized firms	2	7.7	6	23.1	8	15.4
Total	26	100	26	100	52	100

Source: Author

¹⁸⁰ Start-up firms are defined as companies with an age of up to three years (Aldrich et al., 1987).

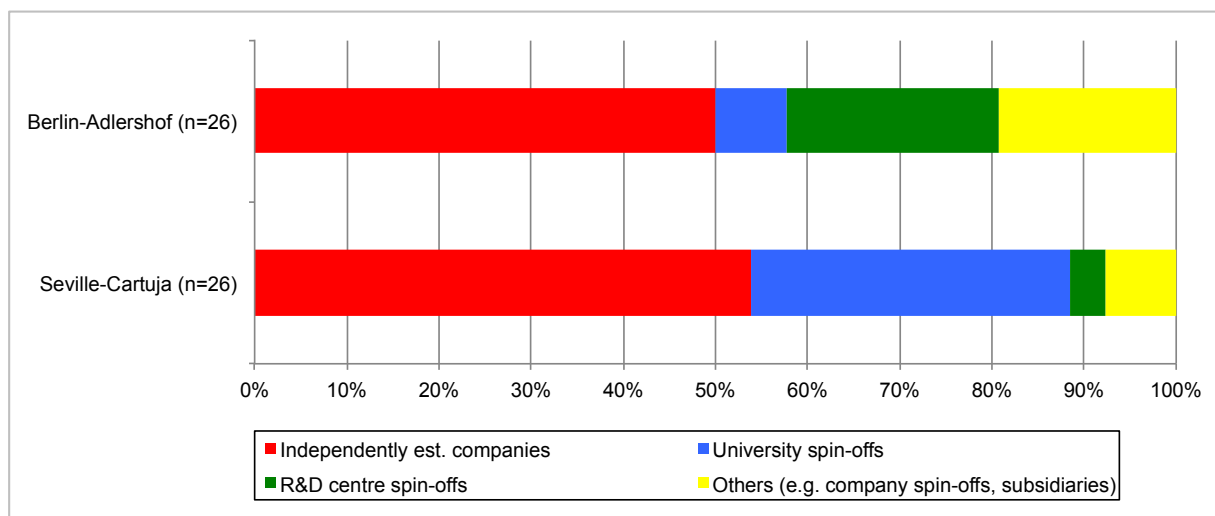
¹⁸¹ For the companies' classification by firm size, the SME definition (by size of employment) of the European Commission (2016) is applied; micro firms (<10 employees), small firms (10-49 employees) and medium-sized firms (50-250 employees).

At the Cartuja science park in Seville, a larger number of businesses are categorized as medium-sized firms, whereas the Adlershof sample includes more small firms.¹⁸²

Furthermore, illustrating the predominantly micro and small size of the firms examined overall, the great majority of ca. 67% of the 52 firms generated sales of less than € 2m in 2009. An additional fraction of ca. 19% indicated an annual turnover of less than € 10m.¹⁸³

Concerning the resident firms' entrepreneurial background, independently established businesses represent the majority in the two science parks' samples (50% and 54%) (see Figure 26).

Figure 26: **Companies by entrepreneurial background**



Source: Author

In addition, the 52 businesses interviewed also include numerous academic spin-off companies (i.e. university spin-offs and spin-offs of non-university R&D institutions). In the STP Adlershof, ca. 31% of the firms have scientific parent organizations, whereas about 39% of the Cartuja-based firms spinned out from universities and R&D institutions.¹⁸⁴

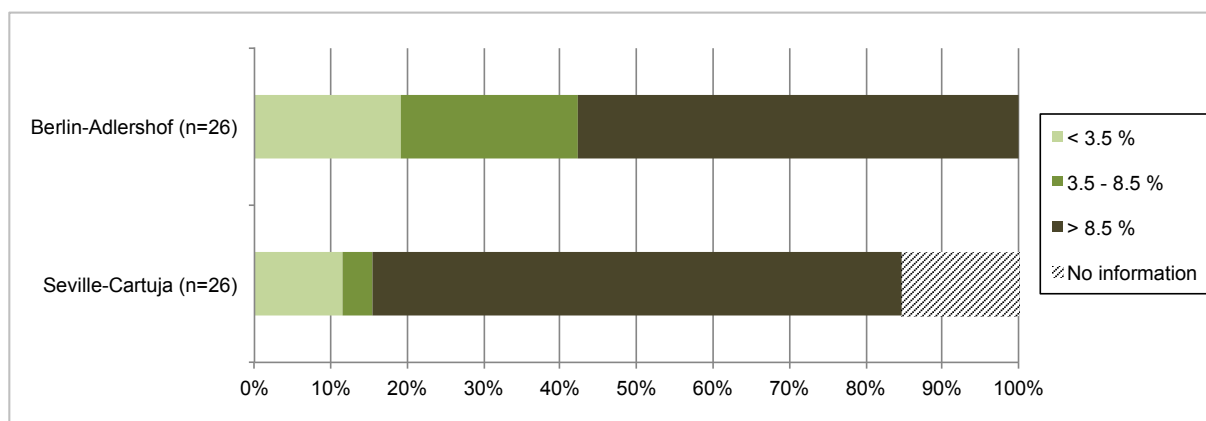
¹⁸² Overall, 16 out of the 18 start-up companies are characterized as micro firms (by size of employment). The 34 mature firms comprise a more heterogeneous structure: micro firms (23%), small businesses (56%) and medium-sized companies (21%).

¹⁸³ Based on the annual turnover, the European Commission (2016) has defined the following categories of SMEs: micro firms (\leq € 2m), small firms (€ 2-10m) and medium-sized firms (€ 10-50m).

¹⁸⁴ Altogether, 15 of the 18 academic spin-offs originate from scientific parent organizations that are located in the two STPs. In case of the Adlershof science park, university-spin offs are linked to the HU-Berlin as parent organization. In case of the STP Cartuja, the university-spin offs are primarily related to the University of Seville, in particular to the School of Engineering.

In addition, the firms' R&D expenditures provide, to some extent, an indication of the companies' inventive capacity and, in turn, absorptive capacity.¹⁸⁵ Accordingly, the large majority of resident firms in the two science parks are characterized by high or advanced levels of R&D intensity (see Figure 27). In total, 33 of the 52 resident firms examined (64%) invested more than 8.5% of their turnover in 2009 in R&D activities.¹⁸⁶

Figure 27: **Companies by R&D expenditures to annual turnover (in %)**



Source: Author

In the Adlershof science park, due to the large number of mature firms, the majority of the examined firms (69%) are regarded as long-time STP residents (more than 3 years). In contrast, at the STP Cartuja a large majority of companies (73%) are defined as young STP residents (up to 3 years), which coincides with the large number of start-up firms included in this sample.¹⁸⁷

The majority of companies (50% and 58%, respectively) are situated in the two STPs' incubators: the two incubators IGZ and OWZ in the Adlershof science park, as well as the Marie Curie incubator in the Cartuja science park. At the STP Adlershof, another eleven firms (42%) are located in one of the five specialized technology centres, for example, in optics

¹⁸⁵ R&D expenditures are often utilized to define industries' and industrial sectors' R&D intensity. This thesis applies the classification of R&D-intensive industries referred to by Kulke (2013) using R&D expenditures in relation to the annual turnover: high-technology (>8.5%), advanced technology (3.5-8.5%) and other manufacturing industries (<3.5%). Alternatively, Legler & Frietsch (2006) have defined slightly different categories: high-technology (>7%), advanced technology (2.5-7%) and low technology (<2.5%).

¹⁸⁶ Commonly, a large share of academic spin-offs (72%) and independently established firms (74%), respectively, is characterized by high R&D expenditures (>8.5%, in relation to the annual turnover in 2009). Also, throughout the different types of firms differentiated by size of employment and company age, large shares of a high R&D intensity is observed for large number of the respective firms: 1) micro firms (70%), small firms (80%) and medium sized firms (37.5%), as well as 2) start-ups (71%) and mature firms (68%).

¹⁸⁷ Several studies (Ter Wal, 2008; Longhi, 1999) have shown that time is considered as an integral determinant of inter-organizational relations, especially in regard to the development of social proximity.

and photonics, ICT and biotechnology, which are also managed by WISTA-MG. In contrast, only two companies reside at the Pavilion of Italy building, which is the business centre managed by Cartuja 93 in the Cartuja science park. The remaining firms in both STPs maintain their own facilities or rent offices from other private or public real estate entities (8% and 35%, respectively).

Overall, similar sets of STP resident firms from the Adlershof and Cartuja science parks are included in the analysis. Despite minor differences, the 52 businesses commonly operate in resembling high-technology industries that also match the distinct technology profiles of the Adlershof and Cartuja science parks. In addition, firms in both STPs predominantly rely on R&D activities. Moreover, a variety of companies characterized by different levels of maturity, sizes and entrepreneurial backgrounds are included in the analysis, as envisioned. Consequently, it provides a sound basis for the analysis of the knowledge relations of a diverse set of STP resident firms to academia in and external to the STP, as well as the identification of important influencing factors and criteria in this respect.

4.2 Adlershof and Cartuja resident firms: Local and non-local knowledge relations to academia

The focus of this chapter is on the analysis of Adlershof and Cartuja resident firms' egocentric knowledge networks to academia. Primarily based on the standardized interviews, I analyse the strength, structure and geography of the firms' knowledge relations to universities and research institutions (**research question 1**). In particular, this chapter examines the significance of different modes of interaction (informal, talent related and formal) with universities and R&D institutions co-located in the two STPs, as well as of interactive ties to non-local academia. Furthermore, the qualitative interviews help illustrate the scope and geography of these interactive linkages. Here, the interviewees were asked to name and describe their interactive ties to specific scientific partner institutions on different spatial scales.

Overall, almost all interviewed resident firms at the two science parks generally maintain knowledge relations to academia. Around 64% of the 52 firms self-assessed their interactive ties to scientific institutions as well-trying and strong knowledge relations overall (see Table 13). An additional fraction of 23% combined still specified them as average or moderate linkages. Yet, important differences concerning the strength of resident firms' knowledge relations to academia are distinguished for the two STPs.

At the Adlershof science park, 14 out of 26 of the interviewed businesses (54%) evaluated their relations to universities and non-university research institutions as either multi-faceted, long-term or as having strong ties. In addition, six businesses (23%) referred to average relations. On the contrary, an additional equivalent number of firms only pointed to limited and sporadic interaction or even no kinds of interactive ties to scientific actors.

Table 13: Evaluation of general level of interaction with academia in the last three years (n=52)

	STP Adlershof		STP Cartuja		Total	
	absolute	in %	absolute	in %	absolute	in %
Multi-faceted, long-term relationships	7	26.9	12	46.2	19	36.5
Strong linkages	7	26.9	7	26.9	14	26.9
Average relations	6	23.1	3	11.5	9	17.3
Moderate linkages	0	0.0	3	11.5	3	5.8
Single, limited transactions	3	11.5	1	3.8	4	7.7
No cooperation	3	11.5	0	0.0	3	5.8
Total	26	100	26	100	52	100

Source: Author

In comparison, resident companies at the Cartuja science park tended to assess their knowledge ties to academia as more intensely.¹⁸⁸ Thereafter, 19 out of 26 of related businesses (73%) rated their links to academia as multi-faceted, long-term relations or as having strong linkages. Furthermore, three firms referred to average or moderate relations. Only four companies indicated rather low levels of interaction with academia overall, i.e. moderate or limited interactive ties.

A more detailed analysis of how the generally evaluated level of knowledge interaction with academia is expressed in distinct modes of local interaction and non-local knowledge relations is laid out subsequently.

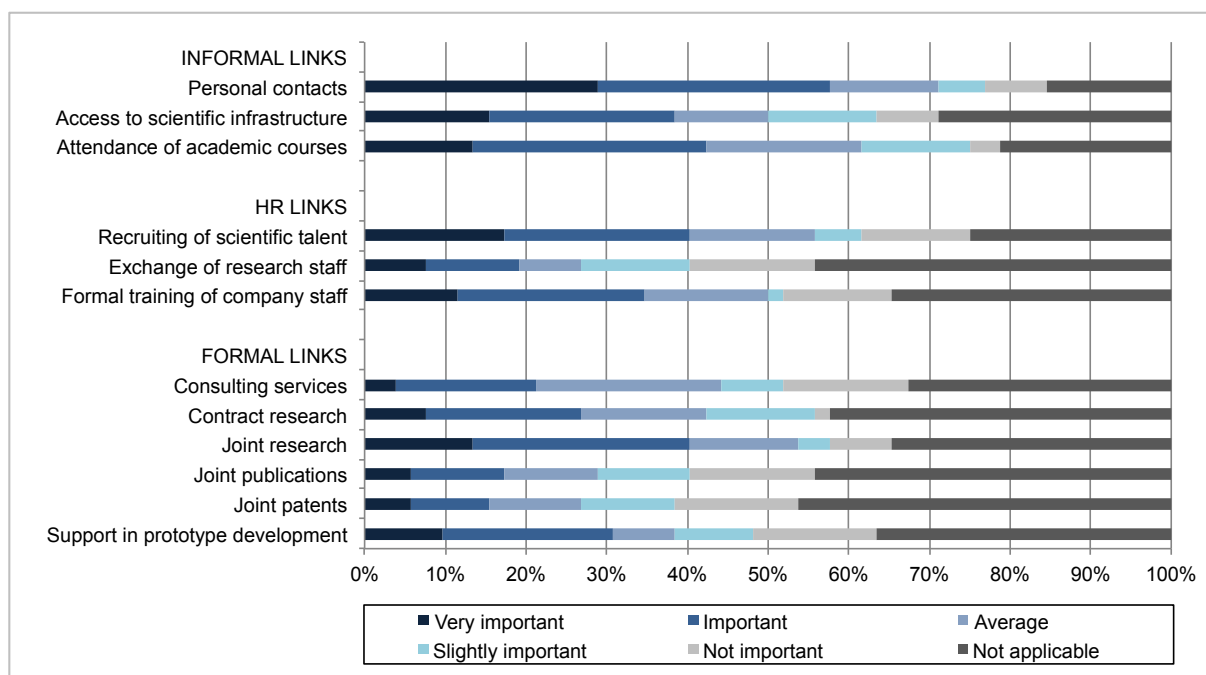
¹⁸⁸ For this variable, it was possible to conduct a t-test. It revealed no statistically significant mean difference on the 5-percent level ($p < 0.05$) between the two STPs: Adlershof (arithmetic mean: 4.2, standard deviation: 1.7) and Cartuja (arithmetic mean: 5.0, standard deviation: 1.2).

Knowledge relations to co-located academia in the STP

In regard to interaction with co-located scientific institutions in the two STPs, the interviewed firms evaluated the relevance of informal, formal and talent-related modes of interaction quite heterogeneously. In addition, varying patterns of local interaction were detected in the Adlershof and Cartuja science parks.

Overall, informal personal contacts were considered as the most important mode of local interaction with academia (see Figure 28). Accordingly, about 58% of the firms in the two STPs evaluated informal personal contacts to co-located researchers as very important or important. This underlines the importance of local buzz (Bathelt et al., 2004) that points to the constant flow of information and facilitated learning processes due to informal personal contacts in spatial clusterings of economic and innovation-related actors. In addition, other informal forms of interaction, such as the use of scientific equipment and the attendance of academic courses (e.g. lectures, seminars and workshops), were also perceived particularly important by similar shares of companies (39% and 42%).

Figure 28: **Evaluation of modes of interaction with co-located academia (n=52)**



Source: Author

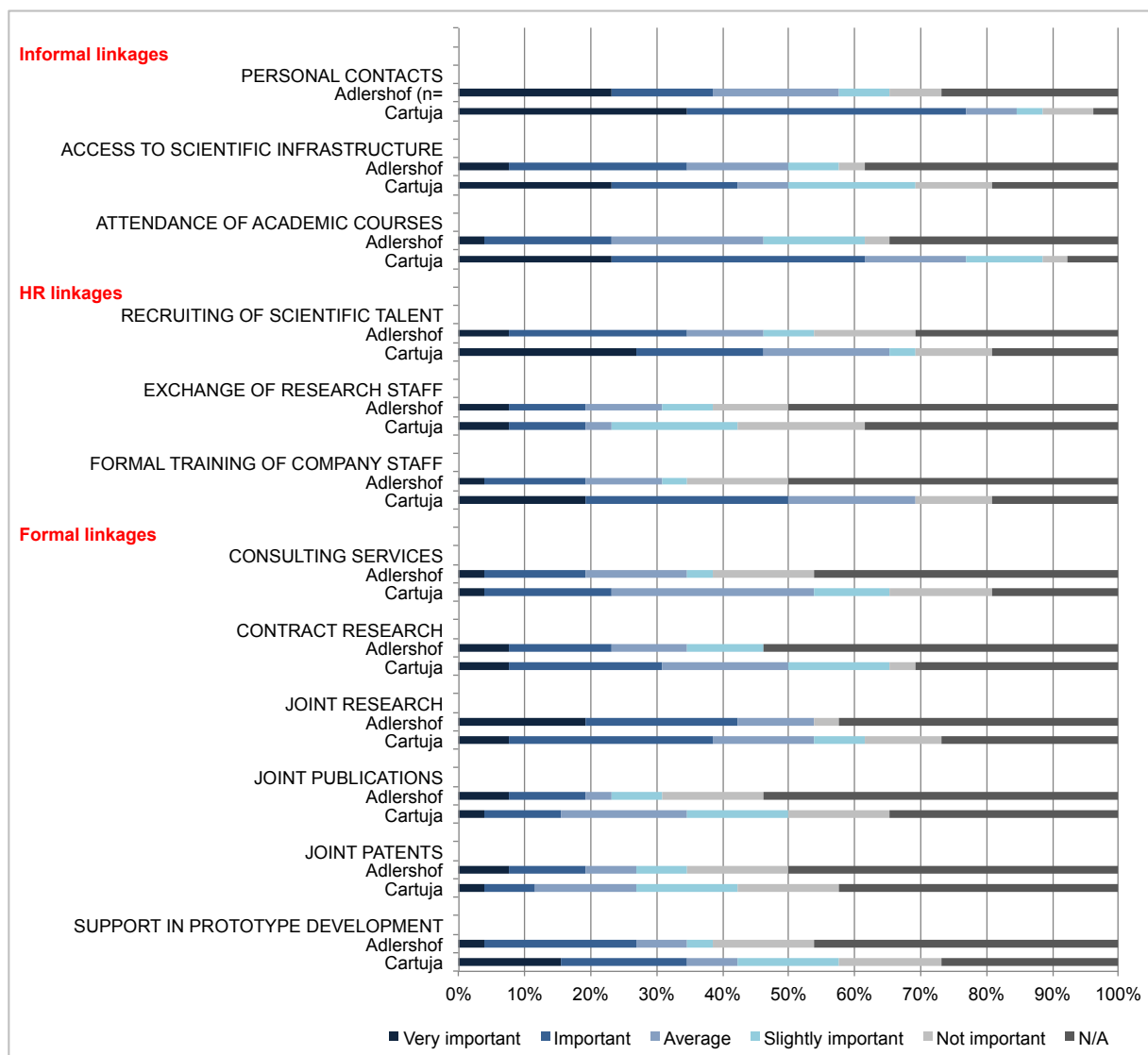
Within the broad range of different HR and formal linkages, selected knowledge channels were emphasized in particular. For the former, ca. 40% of the businesses evaluated the access to new academic talent (e.g. student placements and recruiting of technical staff) as important or very important, while approximately 35% of the firms stressed the importance of formal training of company staff. For the latter, joint R&D projects involving scientific enti-

ties on-site were highlighted by a fraction of about 40% of the firms interviewed. Other forms of formalized cooperation such as support in prototypes development, contract research and consulting services, among others, were assessed less strongly at large. Also, individual companies in the two science parks thoroughly assessed interaction with co-located scientific institutions as not important or not applicable. For these peculiar cases, it is assumed that alternative motivations to anticipated localized knowledge spillovers to locate at the STPs, for example, image advantages and enhanced technology reputation as highlighted by Anttiroiko (2004), are more likely to apply.

In the comparative analysis of the evaluation of informal, HR-related and formal forms of interaction with co-located scientific institutions at the Adlershof and Cartuja science parks, the overall identified fundamental modes of localized interaction are reaffirmed. However, distinct differences between the two STPs are detected concerning the significance assigned to specific forms of interaction.

Accordingly, resident firms in the Adlershof and Cartuja science parks assessed the importance of joint R&D projects (42% and 39%), the use of scientific infrastructure (35% and 42%), the access to young academic talent (35% and 46%) and joint prototype development (27% and 35%) similarly (see Figure 29).

Figure 29: **Comparative assessment of informal, HR and formal linkages with co-located academia in the STP Adlershof (n=26) and STP Cartuja (n=26)**



Source: Author

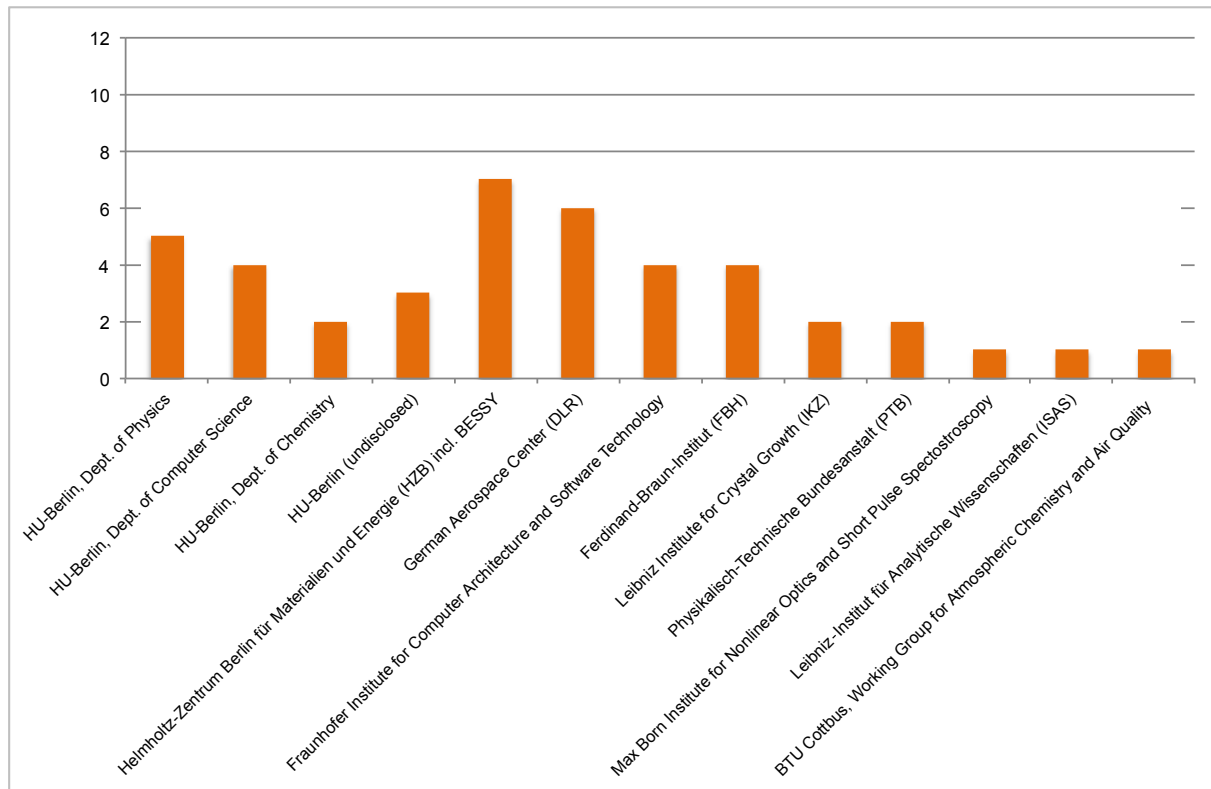
However, Cartuja-based resident firms gave more emphasis to other specific forms of informal and talent-related interaction with local academia than the Adlershof-based companies did. Whereas ca. 77% and 62% of the Cartuja-based firms, respectively, stressed the importance of personal relations and the attendance of academic courses, by comparison only small fractions of about 39% and 23% of the Adlershof resident firms, respectively, allocated high significance to these two informal modes of interaction. In addition, Cartuja resident companies evaluated formal training of firm personnel at co-located scientific institutions considerably more strongly than interviewed firms at the Adlershof science park (50% and 19%, respectively).

In sum, Cartuja resident firms underlined the importance of a large variety of informal, talent-related and formal linkages to co-located scientific institutions. In contrast, the companies interviewed at the STP Adlershof only placed emphasis, but still often to a considerably smaller degree, on selected forms of interaction, for example, personal contacts, use of scientific infrastructure, access to academic talent and joint research projects. Consequently, stronger and more multi-faceted knowledge relations to local academia are identified for resident firms of the Cartuja science park overall, in comparison to the STP Adlershof.

In addition to the quantitative evaluation of localized interaction with academia, the qualitative interviews allowed the mapping of the businesses' specific scientific cooperation partners at the STPs.¹⁸⁹ At the STP Adlershof, selected natural science departments of the Humboldt-Universität zu Berlin (e.g. Department of Physics, Department of Computer Science and Department of Chemistry) were named by multiple firms, especially in conjunction with informal linkages, such as personal contacts and student placements (i.e. access to academic talent), as well as, in individual cases, in terms of formalized cooperation with the framework of joint research projects (see Figure 30).

¹⁸⁹ In the semi-structured interviews, the 52 companies were asked to name the scientific institutions, with which they maintain interactive linkages. However, they not necessarily made statements about the strength of the individual relations. Also, the listings of scientific cooperation partners are not exhaustive.

Figure 30: **Local academic partner institutions of Adlershof resident firms (n=26, non-exhaustive)**



Source: Author

Also, the Helmholtz Zentrum Berlin (HZB) including BESSY, the German Aerospace Center (DLR), the Fraunhofer institute FIRST and the Leibniz-Institut für Höchstfrequenztechnik (FBH) were underlined as prominent cooperation partners.¹⁹⁰ Especially the majority of the university and R&D spin-off firms take advantage of multi-faceted knowledge relations to their co-located parent organizations.¹⁹¹ At large, the quantitative and qualitative results of local interaction between Adlershof resident firms and scientific institutions strongly correspond to previous empirical studies (e.g. Kulke, 2008) that have asserted only moderate and rather informal industry-academia interaction in the science park overall.

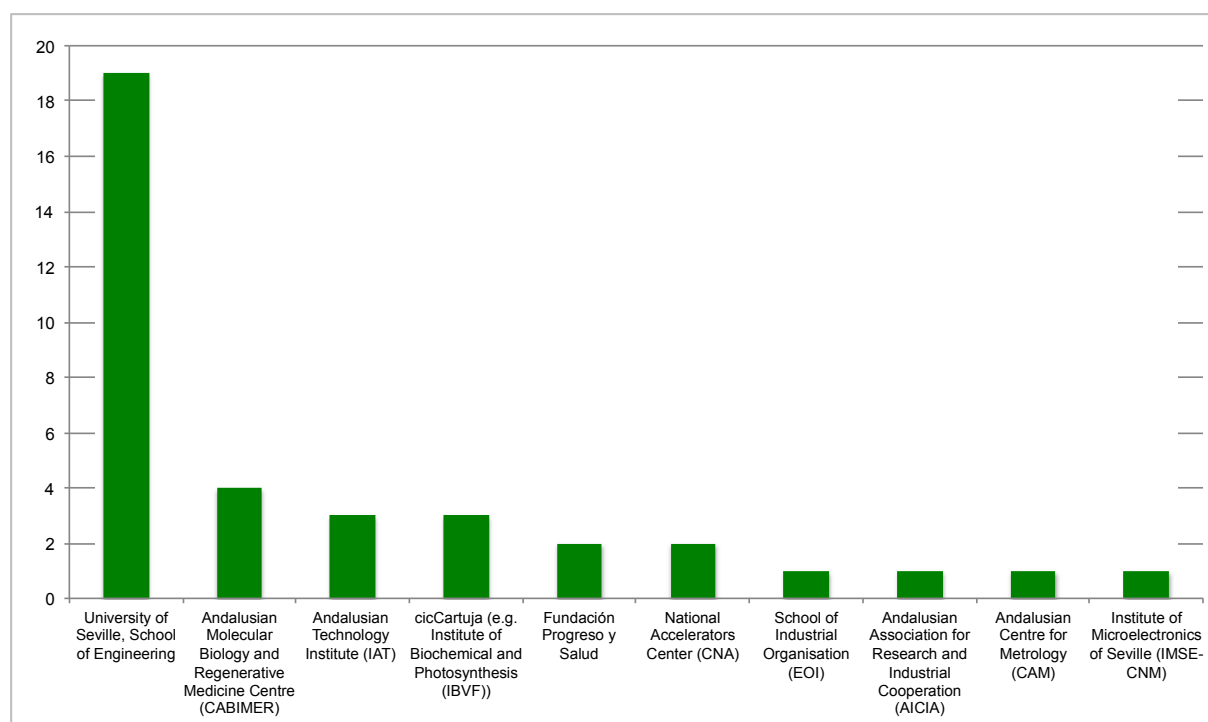
Among the broad range of resident scientific institutions at the Cartuja science park, the School of Engineering of the University of Seville holds a primary position in the knowledge relations of resident companies (see Figure 31). A large number highlighted specific or mul-

¹⁹⁰ Out of the Adlershof-based scientific institutions, the 26 interviewed firms did not name the departments of Geography, Psychology and Mathematics of the HU-Berlin, the HZB Competence Center Thin-Film and Nanotechnology for Photovoltaics Berlin and the Bundesanstalt für Materialforschung und -prüfung (BAM).

¹⁹¹ Five of the six interviewed R&D centre spin-off companies originate from former or recent Adlershof-based non-university R&D institutions (e.g. DLR and FBH).

ti-faceted interactive relations, for example, in terms of personal contacts, student placements, access to scientific equipment, joint research projects and even joint commercialization of research results. In particular, this applies to the university spin-off companies, which originate from the School of Engineering.¹⁹²

Figure 31: **Local academic partner institutions of Cartuja resident firms (n=26, non-exhaustive)**



Source: Author

Only in selected cases were there indications of interactive relations to other scientific institutions at the STP Cartuja, such as, CABIMER, cicCartuja and Andalusian Technology Institute (IAT).¹⁹³ In relation to previous empirical studies, these findings confirm the crucial role of the University of Seville's School of Engineering as the most important local scientific partner for resident companies, as also observed by González Romero (2002). However, whereas González Romero (2002) has indicated only weak interaction between co-located businesses and academia on the whole, the general level of industry-academia

¹⁹² Many of the university spin-offs claimed to have general cooperation agreements with their scientific parent organizations that allow them to realize diverse modes of knowledge interaction (informal, formal and HR links). However, the role of specific types of proximity (e.g. organizational proximity) in these relations is discussed in more detail in Chapters 4.5 and 4.6.

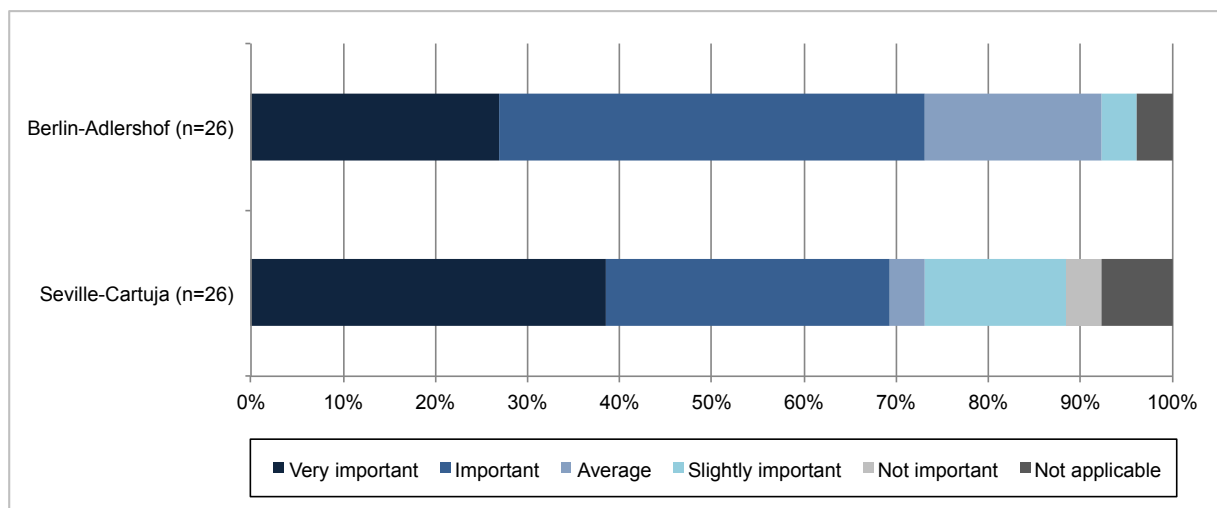
¹⁹³ In the Cartuja case study, the 26 interviewed firms did not name several co-located academic institutions, namely ESIC Business and Marketing School, University of Seville's Faculty of Communication, Andalusian Center for Innovation and Information Technology and Communications (CITIC) and National Renewable Energy Centre (CENER), among others.

relations at the STP Cartuja appears to have increased over time. This is also indicated by the positive development of local inter-organizational R&D projects in the time period between 2004 and 2010, which has been shown in Chapter 3.1.2.

Non-local knowledge relations to academia

Overall, combined about 71% of the businesses interviewed in both science parks emphasized the importance of non-local knowledge relations to academia. Similarly in both science parks, 19 out of 26 Adlershof resident companies (73%) and 18 out of 26 Cartuja resident firms (69%) considered interactive ties to universities and R&D institutions outside the STP as very important and important (see Figure 32). This underlines the increasing importance of extra-local knowledge relations as roots of learning and innovation, as highlighted by various scholars (e.g. Wolfe & Gertler, 2004; Trippl et al., 2009) and expressed in the term global pipelines coined by Bathelt et al. (2004).

Figure 32: **Evaluation of interaction with non-local academia**

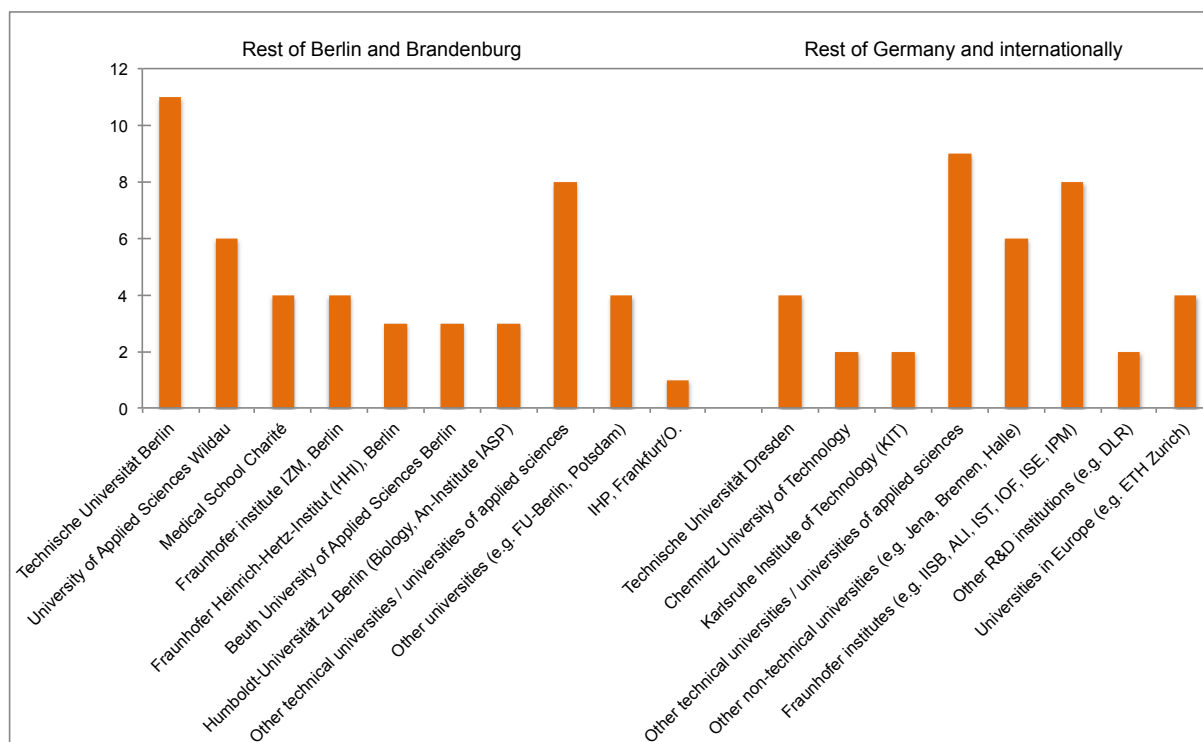


Source: Author

In fact, the large majority of the Adlershof resident companies interviewed stated relations to a wide range of universities and R&D institutions in the region, in Germany and, to a smaller degree, on the international scale (see Figure 33). Notably, the interviewees especially underlined informal and formal linkages to various technical universities and universities of applied sciences (e.g. Technische Universität Berlin and the University of Applied Sciences Wildau), as well as institutes of the Fraunhofer Gesellschaft in the Berlin-Brandenburg region. Thus, the STP resident firms strongly take advantage of the region's diverse scientific landscape, which I described briefly in chapter 3.1.1. These findings coincide with previous research (e.g. Kulke, 2008; OECD, 2010) that has also identified technical universities and universities of applied sciences in the Berlin region as important al-

ternative cooperation partners of Adlershof resident firms, due to a stronger overlap of practice-oriented scientific research and firms' technology areas, in contrast to what the OECD (2010) denoted as unrelated variety of co-located industry and academia in the Adlershof science park.

Figure 33: **Non-local academic partner institutions of Adlershof resident firms (n=26, non-exhaustive)**



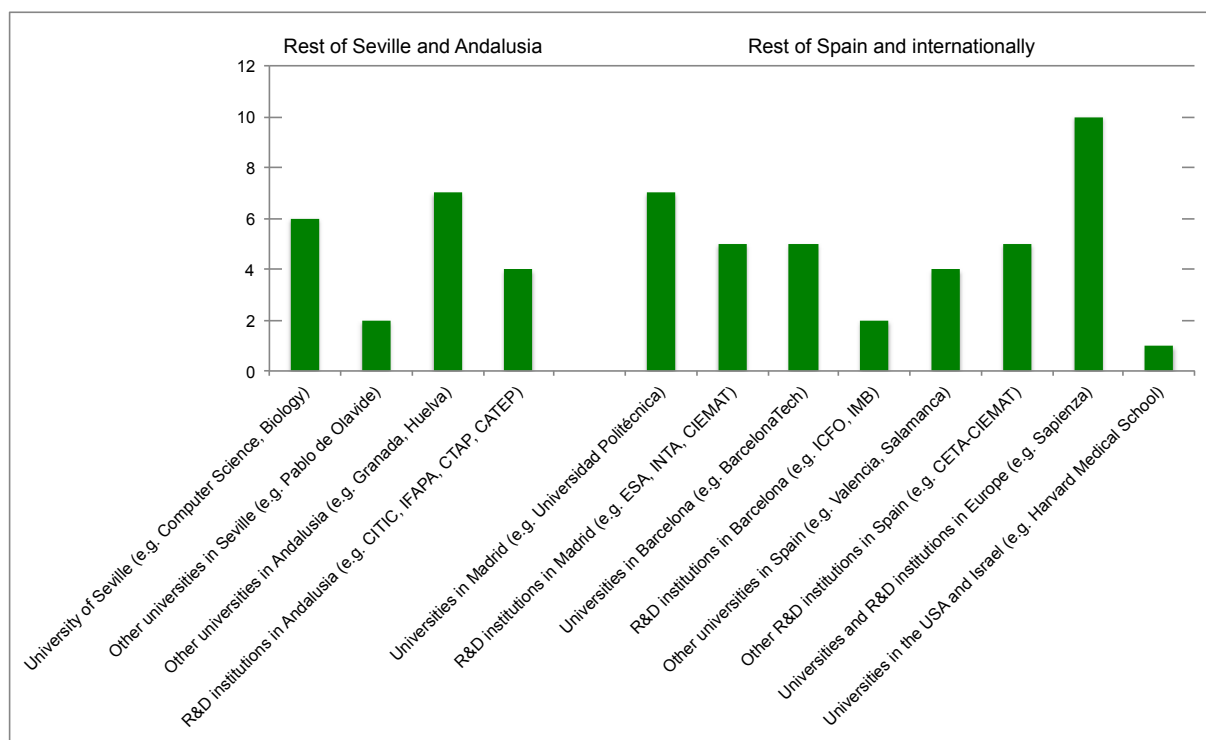
Source: Author

Also on the national scale and, to a smaller extent, on the European scale, the interviewees emphasized multi-dimensional, i.e. informal, talent-related and formal, interaction with various technically oriented universities, universities of applied sciences and multiple Fraunhofer institutes (e.g. Technische Universität Dresden, Chemnitz University of Technology, Karlsruhe Institute of Technology and ETH Zurich) in particular. In regard to formal cooperation with academic partners in Germany, the interviewees especially pointed to industry-academia R&D projects carried out within specific support programmes of the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry of Education and Research (BMBF), among others.¹⁹⁴

¹⁹⁴ The influence and underlying mechanisms of coordinated R&D projects on knowledge interaction between the resident firms of Adlershof and Cartuja and academia in general is subject of detailed analysis in Chapters 4.4 and 4.6.

Also, the large number of academic cooperation partners in the region (i.e. Seville and Andalusia), in Spain and internationally, especially in Europe, reflects the strong relevance of extra-local knowledge relations expressed by a large share of Cartuja resident firms (see Figure 34). On the regional scale, the interviewees stressed especially informal relations, for instance in terms of personal contacts and the use of scientific equipment, to other departments at the University of Seville (e.g. Computer Science, Linguistics, Biology and Pharmacy), which are located in other parts of Seville, as well as the universities in Granada and Huelva. In addition, formalized cooperation in terms of joint research projects was often mentioned, especially within the framework of public support programmes run by the regional government of Andalusia.

Figure 34: **Non-local academic partner institutions of Cartuja resident firms (n=26, non-exhaustive)**



Source: Author

On the national scale, the firms primarily highlighted informal personal contacts and joint R&D projects with multiple universities and R&D institutions in Madrid and Barcelona in particular. Both cities are the major centres of scientific production in Spain (Grossetti et al., 2014).¹⁹⁵ Important academic partners indicated there are the technical universities Universidad Politécnica de Madrid and BarcelonaTech, among others. Moreover, the firms'

¹⁹⁵ 15 universities and ca. 40 R&D institutions are located in the Madrid region (Cámara de Comercio de Madrid, 2017). Eight universities and about 90 R&D institutions are located in the Barcelona region (Barcelona City Council, 2017).

underscored formalized cooperation in terms of joint R&D projects with a variety of scientific institutions throughout Europe. The joint R&D projects on both the national and the European scale were indicated to be often carried out within the framework of public research programmes funded by the Spanish government (e.g. Ministry of Economy and Competitiveness, Ministry of Science and Innovation) and the European Union (e.g. EU Framework Programme for Research and Innovation). Analogue to the increasing development of local collaborative R&D projects, the growing importance of R&D cooperation with non-local partner institutions, especially in Andalusia and Spain, is also reflected in related survey data of Cartuja 93 that I have presented in Chapter 3.1.2.

Box 8: Preliminary summary of the structure and geography of STP resident firms' knowledge relations to academia

In sum, the egocentric knowledge networks of Adlershof and Cartuja resident firms to academia predominantly comprise linkages that are characterized by multi-faceted (i.e. informal, talent-related and formal) modes of knowledge exchange to local and extra-local scientific knowledge sources. These findings reaffirm the notion of the multiplicity of knowledge relations, which has been increasingly highlighted in the economic geography literature (e.g. Grillitsch & Trippl, 2014; Tödtling & Trippl, 2015) and is expressed, for example, in the dichotomy of local buzz and global pipelines popularized by Bathelt et al. (2004).

On the scale of the Adlershof and Cartuja science parks, primarily informal and talent-related interaction and, to a smaller degree, formalized cooperation between the resident firms and co-located academia are observed. This is consistent with findings of other scholarship (e.g. Löfsten & Lindelöf, 2002; Kulke, 2008). Consequently, objectives and expectations linked to the policy tool of STPs in regard to enhanced knowledge externalities are fulfilled to some extent.

In addition, the large majority of resident firms in both STPs placed emphasis on interactive ties to scientific knowledge sources, primarily technically oriented universities and applied research institutions, on the regional and national scale in particular ('regional and national pipelines'). Due to the comparatively stronger evaluation of non-local knowledge relations to academia compared to the specific modes of local interaction, as well as the large number and variety of specified non-local academic knowledge sources, it is assumed that for numerous resident companies examined in the Adlershof and Cartuja science parks non-local relations to universities and research institutions even are more critical than links to co-located scientific institutions.

In the next chapter, I seek to identify specific types of STP resident companies based on the diverse strengths, structures and geographies of egocentric knowledge networks to academia.

4.3 Different types of knowledge seeking resident firms (cluster analysis)

In addition to the general notion of multi-faceted and multi-scalar knowledge networks of STP resident firms in the Adlershof and Cartuja science parks, this chapter aims to develop a typology of STP resident firms' egocentric knowledge networks to academia (**research question 2**). In this respect, I aim to identify the specific characteristics of the different types of firms' knowledge exchange behaviour with academia regarding strength, modes of interaction and geographical dimension. The development of the typology is based on the quantitative analysis. In addition, the qualitative interviews add complementary illustrative information. Subsequently, I aim to use the typology developed for the further analysis of the underlying factors and criteria influencing the development and realization of the businesses' knowledge relationships to academia.

For this purpose, I applied 14 variables measuring different dimensions of business-to-science interaction, which are evaluated by the interviewees in both STPs, in a cluster analysis (see Chapter 3.2.6):¹⁹⁶

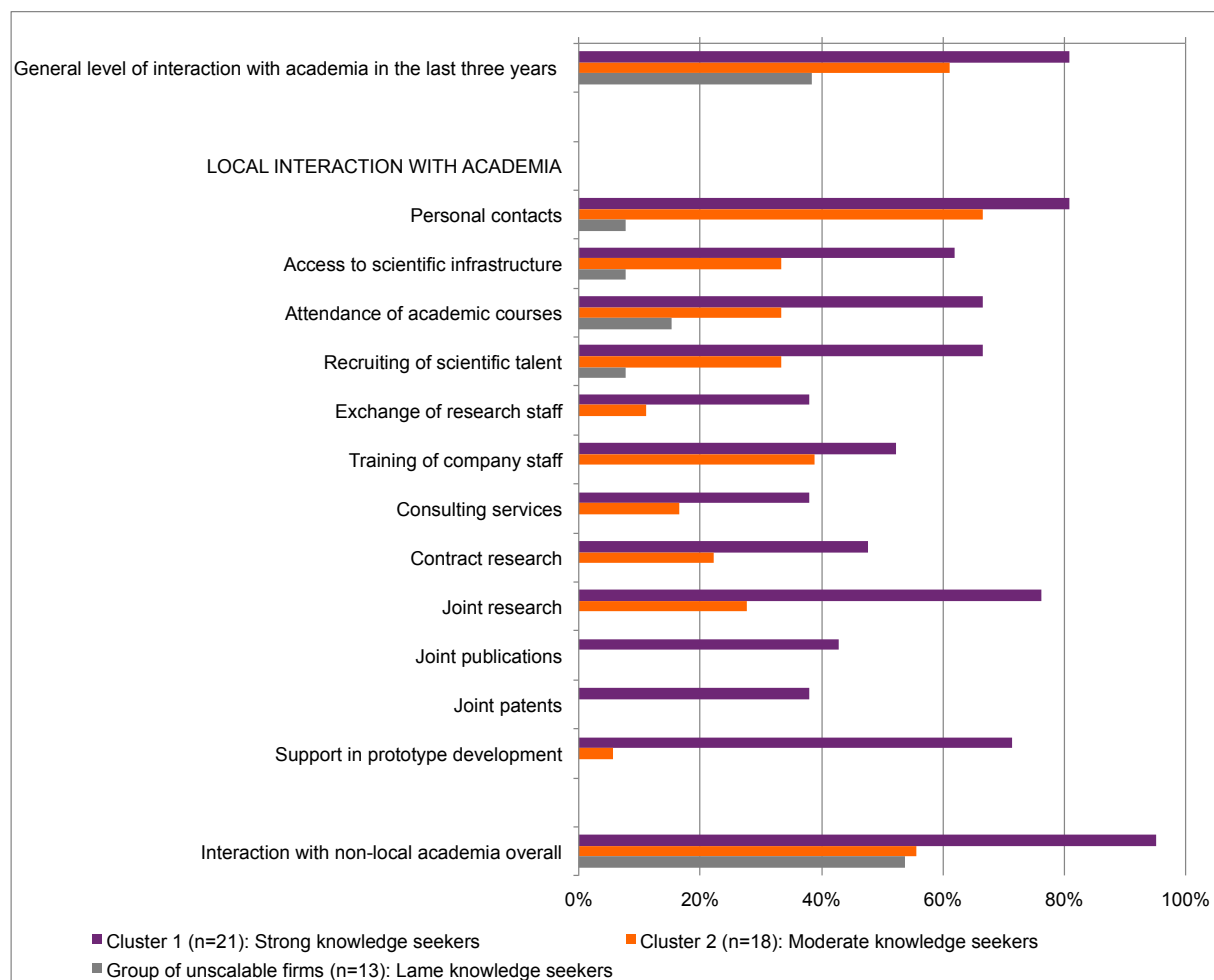
- One variable measuring the general level of interaction with scientific institutions in the last three years,
- Three variables measuring the importance of informal modes of interaction with co-located scientific institutions (e.g. personal contacts and access to scientific infrastructure),
- Three variables measuring the importance of HR links with co-located scientific institutions (e.g. recruiting of academic talent and formal training for company personnel),
- Six variables measuring the importance of specific forms of formal cooperation with co-located academia (e.g. contract research, joint R&D projects and joint patents),
- One variable measuring the importance of interaction with non-local scientific institutions overall.

Two groups of STP resident firms with a distinct structure of knowledge linkages to academia have been identified in the cluster analysis. In combination with the group of so-called unscalable companies (see Chapter 3.2.6), which is considered as a separated

¹⁹⁶ Using an alternative procedure in preparation for the cluster analysis (Ward) (see Chapter 3.2.6), three principal components were retained from the principal component analysis. The three principal components explain the following variables groups: 1) overall quality of interaction in the recent past; 2) informal, talent related and formal channels of localized interaction, and 3) non-local interaction overall.

group in the further analysis, the 52 businesses examined are distributed among the three derived groups as follows: cluster one consists of 21 companies (40%), cluster two comprises 18 businesses (35%), and 13 firms (25%) have been defined as unscalable companies. The distinct features of the three groups are elaborated in more detail in this chapter. At first however, Figure 35 provides an overview of the significance allocated to the different scopes and forms of interaction with academia for the three specific groups.

Figure 35: **Evaluated dimensions of interaction with academia by the three derived groups of STP resident firms (n=52)**¹⁹⁷



Source: Author

¹⁹⁷ For the variable general level of interaction with scientific actors in the last three years, the combined share of firms that stated having multi-faceted, long-term and strong linkages are indicated (in %). For the additional variables of interaction to co-located and non-local interaction academic institutions, the pooled share of firms that evaluated their ties as very important and important are shown (in %).

Cluster one: Strong knowledge seekers (strong multi-dimensional and multi-scalar knowledge relations to academia)

This group comprises 21 businesses. Overall, the STP resident companies in this group frequently and intensely interact and cooperate with universities and R&D institutions, thus taking advantage of multiple forms of knowledge interaction. About 81% of the related firms evaluated their knowledge ties to academia either as multi-faceted, long-term or strong.

In particular, the firms' relations to co-located scientific institutions are characterized by a very solid interaction, throughout the different forms of informal, talent related and formal interaction. As an illustration of the high relevance of informal and HR related localized interaction, ca. 81% of firms of this kind emphasized personal contacts, while two thirds of the firms highlighted the attendance of academic courses and the access to new academic talent. In addition, a majority of the companies in this group (62% and 52%, respectively) also emphasized the access to scientific infrastructure and formal training of firm staff at scientific institutions in the STP: *"We use the contacts for collaboration and for the recruiting of staff. Also, professors recommend the students for internships, you can say they're handpicked."* (ADL_4). Furthermore, in terms of formalized cooperation, more than 76% and about 71% of related companies, respectively, underscored the importance of joint research projects and prototype development activities. Even generally less underlined forms of localized formal cooperation were rated highly by the firms in this category, for example, contract research (48%), joint publications (43%) and, to a smaller extent, joint patents (38%). Often, the firms maintain multi-faceted linkages, combining informal, HR and formal forms of interaction, with local scientific institutions. One firm described its diverse formal ties to scientific institutions in the Adlershof science park: *"(...) secondly, I would name the [name of Adlershof-based R&D institution]. There're even mutual patents. There're mutual research projects that we have done. There also is a cooperation regarding mutual attempts for commercialization activities."* (ADL_17). Typically, such comprehensive interactive ties are based on joint general agreements, which cover various forms of collaboration, with one or multiple academic partner institutions located on-site: *"We have a global cooperation contract with the chair of [name professor]. For example, they conduct surface analytics, which we can't do here. (...) They also offer us lab space within this cooperation. This way, we can use a clean room for our medical stuff. (...) We work together on publications, too."* (ADL_12).

Thus, for the businesses in this category strong localized interaction with academia not only involves widely discussed local buzz and other kinds of informal and HR linkages, but also diverse formalized cooperation. On the one hand, the firms often defined their local knowledge links to academia as essential and stable relationships for knowledge creation

and technological development. As an illustration, one university spin-off firm explained its relationship to its originating university department: *“The basis of the company is basically the School of Engineering of Seville, because the knowledge comes from there. (...) For us, the university is the key in everything, regarding the infrastructure, possibilities of knowledge, possibilities to do projects, cooperation and so on.”* (CAR_19). This corresponds to the notion of strong ties that are critical for the continuous exchange of tacit and complex knowledge, as underlined by Granovetter (1973). On the other hand, ties to other co-located scientific actors, often those with heterogeneous knowledge, are perceived as weak ties: *“There’re only few links to the HU-Berlin, but the [specific university department of natural sciences] is very focused on basic research and not much in our area. (...) Thus, we know about each other and know a few professors, but (...) it’s rather an informal exchange.”* (ADL_19).

Beyond the scale of STPs, almost all companies in this group (95%) also pointed to the high significance of knowledge relations to diverse scientific institutions on the regional, national and international level: *“In the science park in particular with the School of Engineering at the University of Seville. But also, outside the STP Cartuja, we work with three other schools of the University of Seville, the University of Cadiz. And with the Technological Institute in Aragon we work a lot.”* (CAR_11). This corresponds to the growing importance of extra-local knowledge relations for knowledge diffusion and learning stressed in the literature (e.g. Wolfe & Gertler, 2004; Tripl et al., 2009) and termed global pipelines by Bathelt et al. (2004). Compared to firms in the two other derived groups, firms in this group allocated a higher significance to non-local scientific cooperation partners. Similarly to firms’ localized interaction, multi-dimensional knowledge relations (i.e. informal, talent-related and/or formal) are also maintained to scientific knowledge sources external to the STP. One firm described its relations to diverse set of universities throughout Germany: *In regard to cooperation with scientific institutions, Germany is very important for us. At first, I’d stress [name of specific university department and related professor] of the University of Stuttgart. (...) They use our devices. We were in projects together. This is a very important cooperation. (...) We also oversee master theses, currently one from Munster, or interns from universities of applied sciences.”* (ADL_17). Analogue to localized knowledge interaction, the firms’ non-local relationships to academia also comprise strong and weak ties.¹⁹⁸

¹⁹⁸ Corresponding to Granovetter (1973), one firm illustrated the scope of its knowledge relations including local strong ties and increasingly developed project-based, weak ties to non-local academic entities: *“In 2003 / 2004, we started very stable cooperation with the University of Seville. (...) Then, we have applied for R&D projects on the regional level, on the national level. For a few years now we have started to develop European projects with distinct participants, e.g. [names of scientific institutions in UK, Italy and Israel], some research centres in Germany and the Czech Republic.”* (CAR_21).

Due to specific factors such as knowledge specialization and lacking appropriate scientific institutions at the STPs, which has been labelled unrelated variety by the OECD (2010), some businesses of this kind evaluated their extra-local relations to scientific institutions more importantly than linkages in the STP: *“We’re more outside the STP Cartuja. (...) In Andalusia, we’re basically the only ones that do something in this field [author’s note: aerospace].”* (CAR_19). Overall, due to the equivalent reliance on local and non-local knowledge sources, the related businesses reduce the risk of spatial lock-in, as stressed by Petruzzelli et al. (2009) and Boschma (2005). Boschma and Frenken (2010) have even considered the mix of local and extra-local linkages as an optimal level of geographical proximity for interactive learning.

In sum, the very strong, multi-faceted knowledge linkages with academia in the STP and external to the STP of businesses of this type perfectly illustrate the multi-dimensional and multi-scalar process of knowledge sourcing and interactive learning, as Tödtling and Trippel (2015) have put forward. Also, due to the strong level of local links to academia, cluster one can be considered as the ideal-type of knowledge seeking STP resident firms, following the dichotomy of knowledge seekers and image builders in regard to companies’ motives for locating at STPs developed by Royal Kaskoning (2011). For this reason, STP resident companies in cluster one are defined as strong knowledge seekers.

Cluster two: *Moderate knowledge seekers (moderate local, rather informal linkages and non-local pipelines)*

This group consists of 18 companies. Slightly less than the previous group, about 61% of the businesses in this category indicated having multi-faceted, long-term or strong interactive ties with academia overall. Also, regarding the relevance of different forms of local interaction and non-local knowledge relations, distinct differences to cluster one can be observed.

Compared to the previous cluster, interaction with co-located academia of the businesses of this kind is predominantly confined to informal and HR links: *“There are less relations to scientific institutions in Adlershof. These contacts can be characterized as very informal.”* (ADL_16). This applies to informal personal contacts in particular. The importance of local buzz was underlined by two thirds of the firms. In addition, almost 39% of the companies stressed the relevance of academic training of firm personnel on-site. Still, one third of the firms in this category stated that additional forms of informal and talent-related interaction are important, namely the access to scientific equipment and new academic talent, as well as the attendance of academic courses: *“(...) having the University [of Seville] next to us and knowing the professors and the people, and it was a lot easier for us to access people*

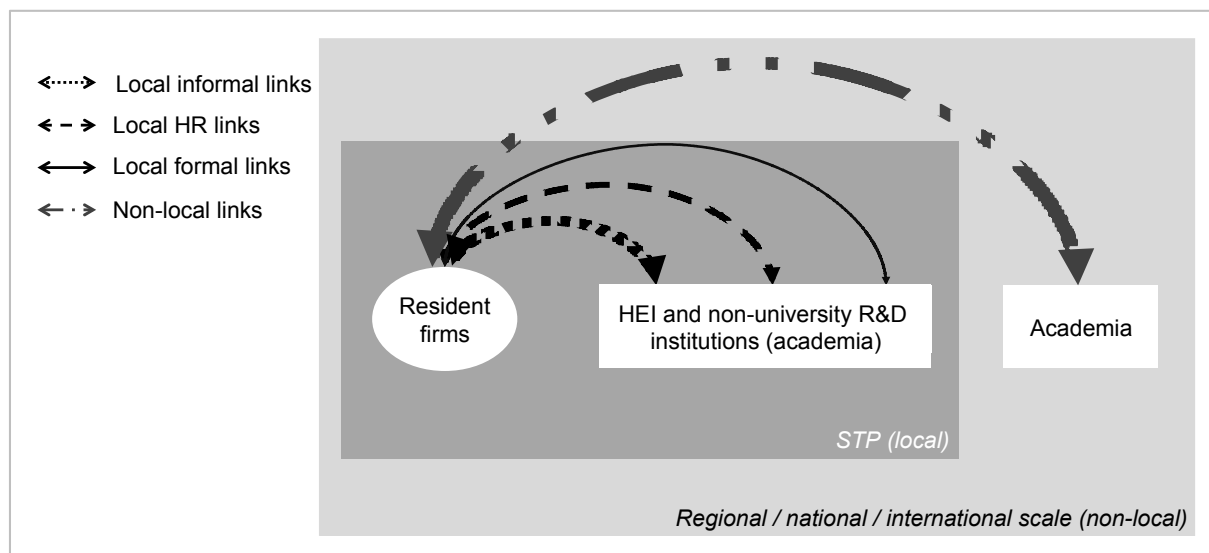
and workers with a good work capacity." (CAR_24). In addition, less emphasis is put on formal cooperation with co-located universities and non-university R&D institutions. Thereafter, a smaller fraction of ca. 28% of the companies underscored joint R&D projects with co-located scientific institutions: *"On some occasions, we can use the services or the equipment that [name of specific co-located R&D institution] provides, and we collaborate with one research group there, too."* (CAR_12). Furthermore, even fewer interviewees (17% and 22%, respectively) placed emphasis on other forms of formalized cooperation, such as contract research and consulting services. Other modes of formal cooperation, for example, joint patents and joint publications were not highlighted by companies of this kind at all. Nevertheless, individual companies in this category pointed to very stable and valuable relationships to specific co-located scientific entities for knowledge interaction and learning underlining the importance of strong ties (Granovetter, 1973). Examples especially include academic spin-offs' linkages to related parent organizations: *"We're a spin-off of the University of Seville, School of Engineering. (...) We have got contracts with the university to develop R&D projects. (...) Apart from the University of Seville (...) there are only few relationships with other science institutions [at the STP]."* (CAR_9). Overall, the patterns of local interaction with academia in terms of, on the one hand, moderate informal and talent-related linkages and, on the other hand, selective formalized interaction linked to joint R&D projects in particular match the results of many empirical studies on STPs (e.g. Vedovello, 1997; Phillimore, 1999; Kulke, 2008).

In contrast, the firms in this category tend to rely more on non-local knowledge sources, underlining the importance of global pipelines. Although to a lower degree than the previously described group, the majority of the firms (56%) assessed their non-local relations to universities and R&D institutions as very important or important. Often, ties to a variety of academic institutions on the regional and national scale (i.e. regional and national pipelines) were named. One firm described its pool of non-local academic knowledge sources: *"We take advantage of the heterogeneous research landscape in Berlin and, to a smaller extent, in Brandenburg. (...) Non-local and regional relations, respectively, (...) are very important and represent the largest share."* (ADL_4). Many of the related firms assigned more weight on their extra-local knowledge relations to academia than to interaction with scientific actors located in the STP. Thus, also numerous of the named non-local links can be characterized as strong ties: *"The network of collaborating entities outside the STP Cartuja is much more important than inside the STP Cartuja."* (CAR_14). Similarly to cluster one, the high significance allocated to extra-local knowledge relations for knowledge diffusion and learning detected for a majority of firms in this category coincides with the findings of a growing literature (e.g. Bathelt et al., 2004). As underlying motives, some firms underlined that they are required to expand their knowledge networks to academia and

look outside the STP due to their specialized technology areas and, in turn, limited congruence with the supply of academic knowledge at the STP: *“Our field of activity is very distinct, and only very few people work in it. (...) [Names of the two scientific parent organizations located in the STP Cartuja] are the only entities in Seville. (...) But, we also have projects with the University of Granada, BarcelonaTech and the University of Santiago de Compostela. We have a European project, in which we work with five European universities. (...) We have many projects like this.”* (CAR_15). This already points to specific barriers in industry-academia relations, which have been emphasized in the literature (e.g. Polt et al., 2001).

Although to a lower and less multi-faceted extent than in case of cluster one, the various knowledge channels as well as local and non-local scientific knowledge sources also reveal the multi-dimensional and multi-scalar process of academic knowledge sourcing for the STP resident firms in cluster two altogether. However, due to the exclusive and yet relatively less emphasized focus on informal and HR linkages to academia in the STP, as well as comparatively moderate non-local linkages, the STP resident firms in this group are labelled moderate knowledge seekers. Figure 36 provides a simplified illustration of the knowledge seeking behaviour of moderate knowledge seekers (the weight of the arrows accords to the ratio, how many firms evaluated the specific modes of interaction with academia as important and very important).

Figure 36: **Knowledge relations to academia of moderate knowledge seekers**



Source: Author

Unscalable companies: *Lame knowledge seekers (no interactive ties or exclusively linkages to non-local academia)*

This group comprises 13 companies. In contrast to the previous two groups, only ca. 39% of associated businesses indicated having strong relations to scientific institutions overall. The comparatively low level of interaction with science overall is especially reflected in the marginally evaluated interaction with co-located academia. One firm exemplified this aspect: *“Currently, there aren’t any relationships to scientific institutions in Adlershof.”* (ADL_11). As an illustration, only ca. 8% of related STP resident firms stressed otherwise strongly emphasized personal contacts. As most relevant form of local interaction to this group, the attendance of academic courses organized on-site was emphasized by a fraction of approximately 15% of the companies.¹⁹⁹

A large variety of rationales for the firms’ marginal interaction with co-located scientific institutions in the STP apply. On the one hand, numerous businesses rather underlined image advantages associated with the location in the STP in contrast to knowledge seeking motives: *“Because a technology park fits well with our products. (...) The technology park entails specific marketing opportunities for us.”* (ADL_24). Also, some firms placed more emphasis on the vicinity to potential customers than the outlook for interaction with resident academia: *“The proximity to clients, the reputation in optics and photonics of Adlershof and the R&D potential were the aspects for Adlershof. But there wasn’t any need to use the R&D potential yet.”* (ADL_5). These findings coincide with alternative expectations of resident firms such as enhanced technology reputation that are linked to STPs, which have been highlighted by Anttiroikko (2004) and Royal Kaskoning (2001), among others.²⁰⁰

On the other hand, other reasons mentioned strongly correspond to prominent barriers impeding industry-academia relations, which are linked to specific characteristics of the firms and scientific institutions as underlined by Polt et al. (2001) and other scholars (see Chapter 2.3.2). Accordingly, multiple interviewees pointed to a lacking congruence between their knowledge demands in specific areas of technology and locally available scientific knowledge. For example, an Adlershof-based company that focuses on transportation could not detect fitting academic partners in the STP: *“In regard to networking [with academia] in our core business, Adlershof allegedly isn’t the optimal location. (...) We rather have contacts to universities in the field of transportation engineering, transportation infrastructure, at best*

¹⁹⁹ In this respect, Royal Kaskoning (2011) has referred to image builders in contrast to knowledge seekers.

²⁰⁰ As I have stated in Chapter 3.2.6, this group includes those firms that were not able to assess the importance of diverse forms of knowledge interaction with co-located scientific institutions using the Likert scale provided and, thus, selected the alternative N/A response option instead. As a result, links to co-located academia are taken as not existent in these cases.

transportation planning.“ (ADL_20). In addition, several firms stressed other activities and priorities, on which they focus limited resources (e.g. time, staff and financial resources), such as business development and sales. One interviewee illustrated this point: *“I don’t want to spend a lot of time with research centres. I rather spend time with potential clients.”* (CAR_13). Also, many of these firms handle innovation-related activities internally: *“At the moment, we don’t have any links to scientific institutions. We do everything ourselves. (...) For now, we [develop our products] based on the know-how that we already have.”* (ADL_23). Ultimately, selected firms lack the knowledge about and contacts to local scientific actors that could be suitable partners and knowledge sources, respectively. Sometimes, individual collaborative activities with scientific partners were not realized successfully, too: *“A while ago, a technical employee tried to make contact to a professor of the HU-Berlin, but it failed. We tried it once or twice and then we gave up on it.”* (ADL_22).

In contrast to very weak local interaction, a large share of companies of this category (54%) placed emphasis on relationships to universities and R&D institutions outside the STP: *“Here in Adlershof, it’s limited. (...) We have many contacts to various Fraunhofer institutes, for example, in Berlin and Cottbus* (ADL_10). Some of the extra-local relations are linked to historically existing ties, for example, in case of university spin-offs that maintain linkages to non-local parent organizations: *“At the moment, we only cooperate with the University of Granada. (...) We are a spin-off company from the University of Granada.”* (CAR_17). Also, several firms of this kind rely on alternative scientific cooperation partners, which better match their specific demands and criteria, outside the STP: *“Once, we intended to cooperate with the Dept. of Computer Sciences of the HU-Berlin. But to me, this couldn’t be realized successfully (...). Now, we only work with universities of applied sciences.”* (ADL_22). Apart from these cases, a large share of the remaining businesses in this group also allocated no crucial significance to extra-local knowledge relations to scientific institutions either, often due to similar causes as it has been outlined for interactive ties to co-located academia.

At large, the businesses of this kind either do not seek to develop linkages to academia at all or almost exclusively rely on extra-local knowledge relations to scientific institutions. In particular, due to the at best punctual informal linkages to co-located academia in the STPs, the companies in this group are labelled lame knowledge seekers overall.

Box 9: Preliminary summary of the typology of knowledge exchange behaviour

As a result of the cluster analysis, a typology of knowledge seeking STP resident firms' has been identified. The following three types of businesses based on specific strengths, structures and geographical scopes of knowledge relations to scientific institutions are differentiated:

1. Strong knowledge seekers: Strong multi-dimensional & multi-scalar knowledge relations
2. Moderate knowledge seekers: Moderate local, rather informal linkages & non-local pipelines
3. Lame knowledge seekers: No local interaction & moderate non-local pipelines

Primarily, the three groups are distinguished by a varying degree of local interaction with academia. While the firms of cluster one maintain strong and versatile links to scientific institutions in the STP, the companies of cluster two only put an emphasis, though to a relatively smaller degree, on informal and talent-related modes of interaction, and joint R&D projects. In stark contrast, the third group of unscalable companies does not pursue any interaction with co-located academia in the STPs. In regard to the latter group in particular, the lack of firms' resources and personal contacts to academia, as well as the insufficient congruence of firms' knowledge demands and local academia's supply of knowledge are detected as critical barriers harming interaction between STP resident firms and academia.

In addition, the three identified types of knowledge seeking STP resident companies placed outstanding and strong emphasis, respectively, on the importance of extra-local knowledge relations to academic knowledge sources in the pursuit for new knowledge and learning. As a result, the mix of local and non-local knowledge relations to academia of strong and moderate knowledge seekers demonstrates the multiplicity of knowledge relations, i.e. the multi-dimensional and multi-scalar process of knowledge sourcing, as well as, an optimal balance of geographical proximity and distance in regard to learning and firms' innovative performance.

Also, for both local and non-local knowledge interaction with academia, firms' relationships to scientific actors stand out as strong ties, while others are characterized as weak ties. Thus, the companies examined tend to combine the advantages of, on the one hand, continuous and stable knowledge interaction as well as, on the other hand, the access to new and more diverse academic knowledge sources.

In the next chapter, I investigate the relevance of a broad range of firm-specific and external channels and settings including distinct KNM instruments. It aims to help explain different qualities and scopes of knowledge networks to academia reflected in the derived typology of knowledge seeking STP resident companies and identify the crucial influencing factors determining successful link creation and knowledge interaction with academia.

4.4 Enabling channels and settings of knowledge relations to academia

This chapter aims to examine the channels and platforms responsible for successful link creation and knowledge interaction with academia for the 52 STP resident firms overall and the three distinct types of companies, namely strong knowledge seekers, moderate knowledge seekers and lame knowledge seekers, in particular (**research question 3**). The quantitative assessment of a variety of channels and settings enabling direct knowledge relations with academia and promoting equivalent indirect linkages was an integral component in the standardized interviews. The quantitative findings on formation and knowledge exchange processes also provide a basis for a comprehensive qualitative analysis of the proximity framework in the firms' knowledge relations to academia in the following Chapters 4.5 and 4.6.

In this regard, on the one hand, I analyse the relevance of specific internal channels as firms' sources of direct knowledge relations to academia. On the other hand, the importance of a broad range of external channels and settings is examined. Here, I consider analogue sets of knowledge network management instruments, which are provided by third actors at the two STPs to initiate and promote industry-academia knowledge relations, i.e. indirect linkages (see Chapters 3.1.1 and 3.1.2). Following the main categories of knowledge management instruments (i.e. information management, people management and external structures) outlined in Chapter 2.3.1, the following types of KNM instruments installed to activate and harness local and non-local industry-academia knowledge relations are considered: STP-related knowledge marketing, local networking events, locally-organized conferences, local and regional intermediary organizations, local technology networks and supra-local public support schemes for joint R&D projects (see Table 14).

Furthermore, a contingency analysis is applied to further validate causal connections between the different types of knowledge seekers associated with distinct knowledge net-

works to academia as well as the use of specific internal and external channels of knowledge sharing ties to academia (see Chapter 4.4.2).

Table 14: **Examined internal and external channels and platforms of resident firms' knowledge relations to academia**

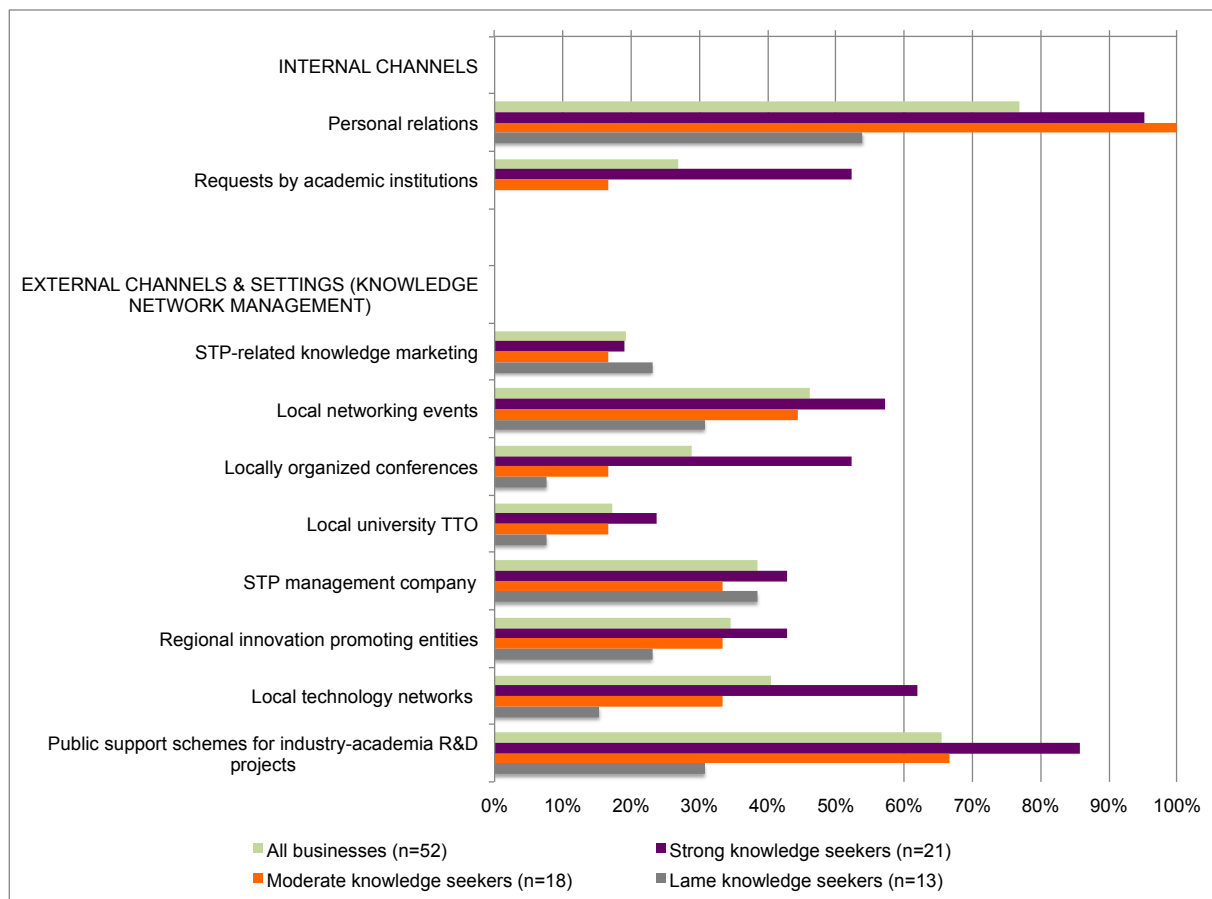
Channels and platforms		STP Adlershof	STP Cartuja
Internal (firm-specific) channels	Personal relationships		
	Requests by academic institutions		
External channels & platforms (KNM)			
Information management	STP-related knowledge marketing	WISTA-MG website and related data-bases, print journals, social media etc.	Cartuja 93 website and related databases, print journals etc.
People management	Local networking events	Forum Adlershof, Academic Lunch, Adlershof Colloquium etc.	Cartuja 93 Working Breakfast, TTAndalucía, Encuentros TT etc.
	Locally organized conferences	microsys-Berlin, PRORA etc.	Foro Innovatec, INNO-VÍA etc.
External / organizational structures (intermediaries, networks, public support programmes)	University TTO	Humboldt-Innovation (HU-Berlin)	OTRI / STCE (University of Seville)
	STP management	WISTA-MG	Cartuja 93
	Regional innovation promoting entities	Berlin Partner, Technologiestiftung Berlin etc.	CTA, CITAndalucía, FIDETIA, Agency IDEA etc.
	Local technology networks	Technologiekreis Adlershof, Forum Adlershof, OpTecBB	Círculo de Empresarios de Cartuja
	Public support schemes for industry-academia R&D projects	TransferBONUS, ProFIT, ZIM, EU Framework Programme for Research and Innovation etc.	Orden única Agency IDEA, INNPACTO, EU Framework Programme for Research and Innovation etc.

Source: Author

4.4.1 Evaluation of internal and external channels as influencing factors for STP resident firms' knowledge relations to academia

Illustrated in Figure 37, the businesses defined as strong knowledge seekers generally rated the importance of the considered internal sources as well as external channels and platforms in terms of KNM instruments for the development and realization of knowledge ties to academia more strongly than the other two identified groups of STP resident firms. For strong knowledge seekers, a broad range of internal and external channels are identified as crucial sources for the creation and realization of knowledge relations to academia.

Figure 37: **Evaluation of internal and external channels for knowledge interaction with academia by types of knowledge seekers (n=52)²⁰¹**



Source: Author

Overall, the large majority of the 52 firms interviewed (77%) assessed that knowledge relations to scientific actors originated from personal relationships. Among the distinct groups identified, almost all firms defined as strong knowledge seekers (95%) and moderate

²⁰¹ The pooled share of firms (in %) is displayed that evaluated the respective variable as very important and important.

knowledge seekers (100%) highlighted the fundamental function of social networks in this regard. A by comparison smaller share of lame knowledge seekers (54%) evaluated likewise. Altogether, these findings coincide with observations of Thune (2009) and Polt et al. (2009). Congruently, they point to the critical role of social embeddedness and social proximity, respectively, in knowledge relations, as Granovetter (1985) and many other scholars have highlighted.

In contrast, only approximately 27% of all companies stressed inquiries by researchers and scientific institutions as an important source for the creation and realization of interactive ties. Also Polt et al. (2009) have only rarely observed the initiation of such linkages by scientists. However, a disproportionate share of ca. 52% of strong knowledge seekers indicated a special significance to this direct channel in particular. On the one hand, this also punctuates the crucial role of personal networks and embeddedness as important enabling factors for firms' knowledge ties to academia. On the other hand, it alludes to the importance of the firms' structural embeddedness in specific networks or communities of practice in conjunction with networked reputation. Also, Menzel (2015) has underlined the important role of mediated trustworthiness among previously unrelated actors in networks.

In terms of external channels and platforms, i.e. ways through which collaborative relationships are formed without prior contact between firms and scientific institutions, the majority of firms (65%) stated the important function of publicly coordinated industry-academia R&D projects. Typically, support programmes run by regional and national governments (e.g. German Ministry of Economy and the Spanish Ministry of Science and Innovation), as well as the European Commission (e.g. Framework Programme for Research and Innovation) manage such projects. Based on the geographical alignment of these programmes, in particular non-local industry-academia knowledge relations are promoted. Coinciding with the specifically strong emphasis on extra-local knowledge relations, especially in terms of regional and national pipelines, firms categorized as strong knowledge seekers and moderate knowledge seekers emphasized publicly subsidized joint R&D projects disproportionately (86% and 67%, respectively). Lame knowledge seekers, who also put emphasis on interactive links to academia external to the STP to a significant degree, only ca. 31% of related businesses rated such public schemes either as important or very important. As emphasized in the literature, publicly subsidized R&D projects provide monetary incentives to stimulate industry-academia relations. Furthermore, they enable firms to gain access to new scientific knowledge and sophisticated scientific equipment, as well as to gain insights into emerging technologies. As a result, R&D collaborations with universities or non-university research institutions have been underlined as crucial settings for the creation

and acquisition of new knowledge that, in turn, enable companies to accelerate their technological development processes and the development of new products (Caloghirou et al., 2001; Perkmann et al., 2011).

Second in importance as an external channel, for roughly 46% of the 52 firms were networking events in STPs. In particular, many strong knowledge seekers (57.1%) stressed the importance of local networking events such as the Adlershof-based Academic Lunch and the Cartuja 93 Working Breakfast. On the other hand, moderate knowledge seekers and lame knowledge seekers underlined such gatherings to a smaller degree (44% and 31%, respectively). By comparison, only a considerably smaller fraction of about 29% of the interviewees overall stated that locally organized industry and scientific conferences are important platforms for the development and realization of knowledge relations to academia, respectively. Notably, however, firms linked to the category of strong knowledge seekers regarded conferences substantially more important (52%) than businesses in the two other groups (17% and 8%, respectively). Thus, those STP resident firms with very strong local and non-local knowledge relations to scientific institutions particularly take advantage of both KNM instruments, networking events and conferences, to form and strengthen linkages with scientific knowledge sources. While local networking events can be considered as gatherings of primarily, but not necessarily exclusively, STP residents, especially conferences with a supra-regional reputation tend to attract national or international knowledge organizations, as Bathelt and Cohendet (2014), among others, have pointed out. For the former, the results correspond to the important function of networking and social events in the development of personal ties and informal exchange of information in Silicon Valley, which has been emphasized by Dahl and Pedersen (2004). Also Harmaakorpi and Melkas (2005) have noted that networking events and other kinds of organized social gatherings are important for initiating first informal personal interaction and increasing social cohesion among knowledge organizations in regional innovation networks. For the latter, the findings in regard to strong knowledge seekers reaffirm Polt et al. (2009), who have also identified conferences and congresses as very important sources for businesses to initiate collaborative relations to scientific institutions. Moreover, the results point to the notion of conferences as temporary clusters (Maskell et al., 2004) and temporary trans-local knowledge nodes (Bathelt & Zakrzewski, 2007) that expose participants to informal flows of information, referred to as local and global buzz, and facilitate the development of knowledge relations to knowledge carriers worldwide.

Furthermore, about 40% of the 52 companies indicated that STP-based technology networks, such as Technologiekreis Adlershof, Forum Adlershof and Círculo de Empresarios

de Cartuja, that comprise resident businesses and scientific are crucial sources of cross-institutional knowledge relations. Among the three categories of knowledge seekers, firms categorized as strong knowledge seekers in particular, namely ca. 62% of associated firms, emphasized this point. In contrast, only small fractions of the other two groups (33% and 15%, respectively) assigned a similar relevance to this KNM tool. Overall, the findings match to observations of other scholars (Brühöfener McCourt, 2009; Jähnke, 2009) who have stressed the positive impact of the formal networks Technologiekreis Adlershof and OpTecBB on local interactive relations in the Adlershof science park. Similarly, Longhi (1999) and Lazaric et al. (2004) have highlighted the positive effects of STP-bound professional networks on local inter-organizational interaction at the Sophia-Antipolis technopole.

From the broader spectrum of organizations intermediating between the private sector and science examined for the KNM systems of the Adlershof and Cartuja science parks, the STP management organizations WISTA-MG and Cartuja 93 were evaluated as most important intermediaries overall. About 39% of all interviewees in conjunction with similar fractions throughout the three specified types of knowledge seekers highlighted this KNM instrument.²⁰² In addition, approximately 35% of the 52 companies underlined the boundary-spanning function of selected regional innovation promoting entities, for example, Berlin Partner and TSB for Berlin, as well as CTA, CITAndalucía and Agency IDEA for Andalusia.²⁰³ In this case, however, the evaluation of the different types of knowledge seekers diverges. Accordingly, an above average share of strong knowledge seekers (43%) and one third of the firms classified as moderate knowledge seekers emphasized their important function as brokers between industry and academia. In contrast, only ca. 23% of lame knowledge seekers rated them as an important channel for interactive ties to scientific actors. By comparison, the interviewees contemplated the significance of the university TTO, Humboldt-Innovation of the HU-Berlin and OTRI/STCE of the University of Seville, as specialized industry-academia interfaces as marginal.²⁰⁴ Consequently, the management companies of both STPs and regional innovation promoting institutions are found to most likely meet the complex functions of industry-academia intermediaries, as the identification

²⁰² Accordingly, ca. 43% of strong knowledge seekers, ca. 33% of moderate knowledge seekers and ca. 39% of lame knowledge seekers evaluated the STP management company as important or very important channel for the formation and realization of interactive links to academia.

²⁰³ The regional innovation promoting organizations Agency IDEA, CTA, CITAndalucía and FIDETIA maintain offices at the Cartuja science park. The Technologiestiftung Berlin had an office at the Adlershof science park between 1994 and 2010 (Expert interview with WISTA-MG, 15 January 2013).

²⁰⁴ Accordingly, ca. 17 of all firms, as well as ca. 24% of strong knowledge seekers, ca. 17% of moderate knowledge seekers and ca. 8% of lame knowledge seekers evaluated the university TTO as important or very important combined.

of appropriate cooperation partners and the mediation of relationships between prior unrelated actors, among others (Howells, 2006). Overall, the observed varying effectiveness of different kinds of intermediary organizations in regard to their anticipated role as active facilitators in knowledge relations between companies and scientific institutions has also been reflected in various previous studies. For example, Fukugawa (2006, 2010) has highlighted the positive outcomes of knowledge brokering activities of incubation managers on interaction between resident firms and research centres in Japanese STPs. Especially the low relevance of university TTO as industry-academia intermediaries has also been pointed out by many scholars, for example, Schmoch (1999) and Polt et al. (2009).

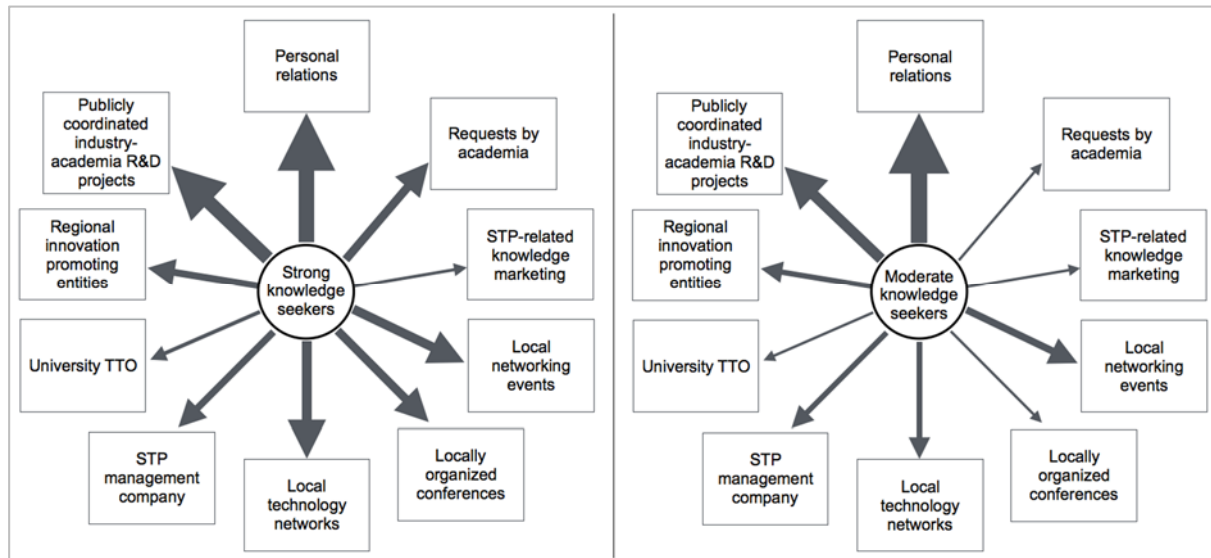
Ultimately, only a small number of the interviewees overall (19%) and of the three defined groups rated STP-related knowledge marketing as important channel enabling the formation of interactive ties to scientific institutions. In comparative terms, especially lame knowledge seekers (23%) stressed this KNM instrument, which aims to facilitate the identification of suitable knowledge and related local knowledge sources at the STP in particular.²⁰⁵ Thus, the results do not reaffirm findings of Lazaric et al. (2004, 2008) that have emphasized enhanced knowledge interaction in the ICT cluster of the Sophia-Antipolis technopole due to the STP's improved knowledge marketing in terms of knowledge and technology mapping. However, it has also been asserted that these positive effects were strongly affected by the active involvement of relevant resident organizations in the redesign process of the information management system.

In sum, in addition to personal networks as crucial sources for the STP resident firms' knowledge relations to academia, specific KNM instruments function as important transfer channels and platforms, through which firms build interactive relations with previously unrelated scientific institutions. This applies to publicly subsidized and coordinated R&D projects, local networking events, local technology networks and selected intermediaries (i.e. STP management firms and regional innovation agencies) in specifically. Furthermore, inquiries by scientific institutions and locally organized conferences are additional crucial sources of strong knowledge seekers in particular. By comparison, firms specified as strong knowledge seekers more strongly take advantage of a broader range of enabling channels in terms of both internal sources and KNM instruments than the other two groups of STP resident companies. Figure 38 provides a simplified, comparative illustration of the internal and external channels that affect knowledge interaction with academia of the two

²⁰⁵ Ca. 19% and 17% of the firms identified as strong and moderate knowledge seekers, respectively, evaluated STP-related knowledge marketing strongly.

clusters of strong knowledge seekers and moderate knowledge seekers (the weight of the arrows accords to the ratio, how many firms evaluated the specific channels enabling knowledge relations to academia as important and very important).

Figure 38: **Enabling channels and settings utilized by strong knowledge seekers and moderate knowledge seekers**



Source: Author

4.4.2 Contingency analysis

In addition to the quantitative analysis in the previous sub-chapter, I have conducted a contingency analysis to further substantiate the varying assessments of internal and external enabling channels of knowledge relations to academia in relation to the three different types of knowledge seekers. The contingency analysis examines whether the observed frequencies are statistically significant from the expected frequencies.²⁰⁶ Furthermore, the chi-square test of homogeneity gives an indication whether the variables are equally distributed in the different groups. The phi coefficient and contingency coefficient measure the degree of interaction between the relevant variables. A phi coefficient that is higher than 0.3 indicates a strong interaction of the relevant variables. Moreover, the contingency coefficient is based on the phi coefficient. Its value ranges from 0 to 1 (Backhaus et al.,

²⁰⁶ The contingency analysis enables the consideration of different scales of variables as any kind of variable (categorical, ordinal etc.) can be transformed to the nominal scale. However, it has to be acknowledged that such transformation is related to a loss of information (Backhaus et al., 2008). For the contingency analysis, two categories of the businesses' evaluations of the internal and external channels and settings have been formed: 1) ratings of very important to important and 2) ratings of average to N/A.

2008). Using a 3x2 contingency table, Table 15 shows the observed frequencies (absolute and relative) of the items examined for the three identified types of knowledge seekers.

**Evaluation of internal and external channels for knowledge relations to academia by different types of knowledge seekers
(contingency analysis, n=52)**

	Strong knowledge seekers (n=21)		Moderate knowledge seekers (n=18)		Lame knowledge seekers (n=13)		<i>Total</i>	
	absolute	in %	absolute	in %	absolute	in %	<i>absolute</i>	<i>in %</i>
<i>Internal channels</i>								
Personal relations								
Very important - important	20	95.2%	18	100%	7	53.8%	45	86.5%
Average – not applicable	1	4.8%	0	0%	6	46.2%	7	13.5%
Requests by scientific institutions								
Very important - important	11	52.4%	3	16.7%	0	0%	14	26.9%
Average – not applicable	10	47.6%	15	83.3%	13	100%	38	73.1%
<i>External channels and platforms (KNM instruments)</i>								
STP-related knowledge marketing								
Very important - important	4	19.0%	3	16.7%	3	23.1%	10	19.2%
Average – not applicable	17	81.0%	15	83.3%	10	76.9%	42	80.8%
Local networking events								
Very important – important	12	57.1%	8	44.4%	4	30.8%	24	46.2%
Average – not applicable	9	42.9%	10	55.6%	9	69.2%	28	53.8%
Locally organized conferences								
Very important - important	11	52.4%	3	16.7%	1	7.7%	15	28.8%

	Strong knowledge seekers (n=21)		Moderate knowledge seekers (n=18)		Lame knowledge seekers (n=13)		Total	
	absolute	in %	absolute	in %	absolute	in %	absolute	in %
Average – not applicable	10	47.6%	15	83.3%	12	92.3%	37	71.2%
Local university TTO								
Very important - important	5	23.8%	3	16.7%	1	7.7%	9	17.3%
Average – not applicable	16	76.2%	15	83.3%	12	92.3%	43	82.7%
STP management company								
Very important - important	9	42.9%	6	33.3%	5	38.5%	20	38.5%
Average – not applicable	12	57.1%	12	66.7%	8	61.5%	32	61.5%
Regional innovation-promoting entities								
Very important - important	9	42.9%	6	33.3%	3	23.1%	18	34.6%
Average – not applicable	12	57.1%	12	66.7%	10	76.9%	34	65.4%
Local technology networks								
Very important – important	13	61.9%	6	33.3%	2	15.4%	21	40.4%
Average – not applicable	8	38.1%	12	66.7%	11	84.6%	31	59.6%
Public support schemes for industry-academia R&D projects								
Very important - important	18	85.7%	12	66.7%	4	30.8%	34	65.4%
Average – not applicable	3	14.3%	6	33.3%	9	69.2%	18	34.6%
Total	21		18		13		52	

Source: Author

As a result of the contingency analysis, the two internal channels, i.e. personal relationships and direct offers by scientific institutions, as well as the three KNM instruments public programmes for joint industry-academia R&D projects, locally organized conferences and local professional technology networks all show a statistically significant distribution among the three types of knowledge seekers that is not homogenous (see Table 16).

Table 15: Contingency analysis' results (degrees of freedom= 2, $\alpha < 0.05$), n=52

	Chi-square	Phi coefficient	Contingency coefficient
<i>Internal channels</i>			
Personal relationships	16.091	0.556	0.486
Requests by scientific institutions	12.670	0.494	0.443
<i>External channels & platforms (KNM instruments)</i>			
Locally organized conferences	9.802	0.434	0.398
Local technology networks	7.786	0.387	0.361
Public support schemes for industry-academia R&D projects	10.73	0.454	0.414

Source: Author

In these cases, the relevant Chi-square values show the rejection of the null hypotheses of a homogeneous distribution of the relevant variables in the three groups (degrees of freedom= 2, $\alpha < 0.05$). With phi coefficients between 0.38 and 0.56 and contingency coefficients between 0.36 and 0.49, the degree of interaction between the internal channels and specific KNM instruments named here and the typology of knowledge seekers can be characterized as relatively strong. The standardized residuals also prove the direction of the relationship of the two independent variables (Bahrenberg et al., 1999; Backhaus et al., 2008).

In this sense, firms that rated the selected two internal channels and three KNM tools as important or very important are clearly over-represented in the group of strong knowledge seekers, while lower evaluations are clearly under-represented.²⁰⁷ In regard to the type of moderate knowledge seekers, related companies with assessments of important or very important are over-represented in regard to the item personal relationships in specifically and, to a smaller degree, concerning the item public support programmes for industry-

²⁰⁷ For the group of strong knowledge seekers, the following standardized residuals are shown for the specific assessments (very important-important | average-N/A) of the five items discussed: personal relationships (0.4 | -1.1), requests by academia (2.2 | -1.4), public support programmes for industry-academia R&D projects (1.6 | -1.2), locally organized conferences (2.0 | -1.3) and local technology networks (1.6 | -1.3).

academia R&D projects.²⁰⁸ In contrast, companies in this group with assessments of important or very important for the items direct offers by scientific institutions, locally organized conferences and local technology networks are under-represented. In the group of lame knowledge seekers, firms that evaluated all five relevant items strongly are clearly under-represented.²⁰⁹

Consequently, STP resident firms that placed emphasis on the importance of requests by scientific institutions as well as the three KNM tools locally organized conferences, formal networks in the STP and publicly subsidized R&D projects on the regional, national or European scale have the strong tendency to be categorized as strong knowledge seekers. Thus, these firms tend to have strong and multi-faceted knowledge relations with academia in the STP and external to the STP. Moreover, the STP resident firms that highlighted the fundamental influence of their personal relationships on successful link creation and realization of knowledge interaction with academia tend to be classified as either moderate knowledge seekers or, slightly less likely, as strong knowledge seekers. Thereafter, they also show a higher likelihood to maintain comparatively stronger and versatile local and non-local interactive ties with academia.²¹⁰

At large, the results of the contingency analysis indicate that the use of specific internal and external channels and settings determines the different strengths and geographies of the STP resident firms' knowledge relations to academia. Accordingly, the multi-faceted, very stable linkages of strong knowledge seekers to academia in the STP and external to the STP are the result of, firstly, the strong exploitation of personal contacts and direct in-

²⁰⁸ For the group of moderate knowledge seekers, the following standardized residuals are shown for the specific assessments (very important-important | average-N/A) of the five selected items: personal relationships (0.6 | -1.6), requests by academia (-0.8 | 0.5), public support programmes for industry-academia R&D projects (0.1 | -0.1), locally organized conferences (-1.0 | 0.6), and local formal networks (-0.5 | 0.4).

²⁰⁹ For the group of lame knowledge seekers, the following standardized residuals are shown for the specific assessments (very important-important | average-N/A) of the five selected items: personal relationships (-1.3 | 3.2), requests by academia (1.1 | -1.9), public support programmes for industry-academia R&D projects (-1.5 | 2.1), locally organized conferences (-1.4 | 0.9), and local technology networks (-1.4 | 1.2).

²¹⁰ Note: In an additional contingency analysis, I tested the influence of the specific firm characteristics on the derived typology of knowledge seekers: location (STP case study), firm age, firm size (in terms of employment), R&D expenditures, duration of STP residency and entrepreneurial origin. The contingency analysis reveals a significant inhomogeneous distribution of the two different categories of firms' employment: 1) <10 employees and 2) ≥10 employees (Chi-square= 6.692, degrees of freedom= 2, $\alpha < 0.05$). Thus, the latter category is over-represented in cluster one (strong knowledge seekers) and cluster two (moderate knowledge seekers), while it is underrepresented in the group of unscalable companies (lame knowledge seekers). Consequently, companies with ten and more employees tend to be classified as strong or moderate knowledge seekers and, thus, tend to have proportionately stronger interactive ties with academia. These findings coincide with results of previous studies (e.g. Cohen et al., 2002; Fontana et al., 2006). Using a 3x2 contingency table, Table A8 in the Appendix shows the frequencies of the selected firm characteristics for the three groups of knowledge seekers. However, this thesis only focuses on the analysis of internal as well as external enabling channels and related underlying mechanisms as influencing factors of the industry-academia knowledge relations.

quiries of scientific actors, as well as, secondly, the thoroughly planned use of specific KNM instruments, namely publicly subsidized industry-academia R&D projects, conferences and local technology networks. Due to the characteristics and geographical focus of the different channels, assumptions concerning their specific influence on local and/or extra-local linkages can be made. Amongst other channels, the two internal channels named both enable strong, multifaceted local and non-local knowledge relations in general, whereas publicly subsidized industry-academia R&D projects to non-local academia and conferences primarily are instrumental for the development of the strong linkages to non-local academia (regional, national and European pipelines). The participation in local technology networks primarily contributes to the multi-faceted and strong linkages to co-located academia in the STPs.

Box 10: Preliminary summary of enabling channels and platforms

In sum, the firms specified as strong knowledge seekers strongly take advantage of a large variety of enabling channels to build and maintain knowledge ties to academia; on the one hand, in terms of internal sources, i.e. personal relations and requests by academia, and, on the other hand, specific KNM instruments, namely publicly subsidized R&D projects, networking events, conferences, technology networks, the STP management firms and regional innovation promoting entities. With the exception of inquiries of scientific institutions, the same applies to moderate knowledge seekers, although for most relevant channels to a rather moderate degree. In contrast, the companies categorized as lame knowledge seekers primarily only utilize personal contacts and individual KNM tools, also to a comparatively much lower degree.

From the contingency analysis, it seems fair to conclude that strong, multi-faceted linkages to scientific institutions both in the STP and external to the STP primarily are a result of a firm's strong social and structural embeddedness, as well as a firm's keen use of specific KNM tools, namely publicly subsidized industry-academia R&D projects, conferences and local technology networks. It is assumed that the KNM tools highlighted affect a firm's embeddedness.

The strong significance of non-local knowledge relations with academia in all three types of knowledge seekers reaffirms the notion put forward in the recent academic discussion that geographical proximity alone is not a necessary and sufficient criterion for knowledge interaction to take place. Instead, this aspect, as well as the importance of personal relations and other internal and external channels points to other forms of non-spatial proximity as critical criteria of successful link creation and knowledge interaction with academic institutions. In this respect, I examine the relation of non-spatial forms of proximity, in addition to geographical proximity, to the STP resident firms' knowledge relations to academia in more detail in Chapter 4.5. Also in regard to the systematic organization of proximity I analyse the underlying mechanisms of specific KNM instruments in Chapter 4.6.

4.5 Proximity framework in firms' knowledge relations to academia

The academic discussion of the proximity framework determines specific functions and, thus, a certain hierarchy to the different types of non-spatial and spatial proximity in knowledge relations (see Chapter 2.2). More or less two tenets of the proximity framework have been identified. Firstly, geographical proximity is not considered be a necessary and

sufficient criterion for knowledge interaction to take place. Secondly, non-spatial forms of proximity are regarded as more critical factors in this respect. Whereas a certain level of cognitive proximity is commonly recognized as a necessary prerequisite, the roles of social, organizational and institutional proximity as critical or auxiliary criteria for the creation of interactive links and related knowledge sharing processes have not been unequivocally clarified (Boschma, 2005; Mattes, 2012).

Based on the qualitative interviews with the 52 resident companies at the Adlershof and Cartuja science parks, in this chapter I seek to explore what types of proximity and proximity configurations, respectively, matter in the firms' knowledge relations to scientific institutions (**research question 4**). In conjunction with findings of the quantitative analysis in the previous chapters, the qualitative analysis aims to shed light on what specific dimensions of proximity are necessary, critical and auxiliary criteria for successful link creation and knowledge interaction between STP resident firms examined and science.

4.5.1 Cognitive proximity as essential criteria for knowledge interaction

In the literature, cognitive proximity, which is defined as the similarity of actors' knowledge bases, is commonly understood as a necessary prerequisite for value-added knowledge relations to occur. Thus, a certain overlap of knowledge bases is essential to enable effective understanding and communication, as well as successful integration and exploitation of new external knowledge (Boschma, 2005). Consequently, actors often seek to build interactive ties to other actors that possess similar references and knowledge bases, for example, in communities of practice, in order to effectively process the exchanged knowledge (Nooteboom, 2000a).

For the knowledge relations to academia of the resident firms interviewed, sufficient cognitive overlap and a specialized expertise of scientific actors, which matches the businesses' distinct knowledge demands, are essential for the formation of interactive linkages and related knowledge interaction. Generally, the knowledge relations to scientific actors have to cater to the firms' specialized knowledge demands, as the absorbed external scientific knowledge is intended to contribute to the companies' technological development of new, innovative products, thus generating tangible results of economic value for the companies. In particular, the businesses, who have been specified as strong and moderate knowledge seekers, stressed this decisive factor: *"Research institutions with their*

*specific knowledge in certain issues such as energy efficiency can really contribute to our projects and improve our products and services.” (CAR_2).*²¹¹

Thereafter, based on the specific tasks and related knowledge demands, the interviewed companies scan, identify and contact suitable scientific knowledge sources (i.e. universities and R&D institutions) that dispose of the needed specialized resources (e.g. knowledge and equipment) to help them in solving specific problems: *“They are the only ones that we know in Spain that can do this. That’s why we don’t do it with somebody else.” (CAR_19).* Thus, a firm’s interactive ties to science linked to learning are a result of both already existing relations, as well as rational planned knowledge-creation activities with selected fitting knowledge sources: *“I’m always looking for who has got technologies that exactly fit to our concept.” (ADL_21).*

Sufficient cognitive proximity was referred to either in terms of related knowledge areas or certain knowledge diversity. For the former, strongly overlapping scientific knowledge in relation to a firm’s technological expertise ensures the capability to aid in the solving of a firm’s specific tasks and problems: *“Our criterion for cooperation is that the people are capable (...). And also, complementing in our work, i.e. a research group that is doing something similar than what we do, and vice versa.” (CAR_24).* Such relations characterized by a strong cognitive overlap of knowledge bases can enhance the firm’s technology development significantly and, consequently, were often underlined as strong ties: *“With other people, we don’t cooperate as closely as with [name of a university professor]. This is based on the substantial overlapping of the area of work and research, respectively.” (ADL_12).* For the latter, many interviewees pointed to the importance of accessing heterogeneous, but still complementary scientific knowledge in order to stimulate novel combinations of knowledge and, in turn, innovation: *“At best we will get in contact with somebody that could do certain activities for us that we don’t know of yet.” (CAR_14).* Also, Boschma (2005) and Thune (2009) have argued that the balance of related and dissimilar knowledge is an important driver for the creation of novel ideas and technologies and, thus, learning and innovation. However, too large cognitive distance in terms of unrelated knowledge and the lack of absorptive capacity of the firm are hampering effective communication and, in turn, knowledge sharing. One interviewee illustrated this aspect: *“The precondition for cooperation is that both partners have the expertise. I presume this to*

²¹¹ Similarly, firms categorized as lame knowledge seekers underlined complementary expertises in their statements about the fundamental criteria for interaction with academia: *“The ideal cooperation with science would be that a research institution conducts the materials research, and we take part in the development of the industrial application.” (ADL_11).*

be the case for an R&D institution, but we also have to be capable to absorb the relevant knowledge.” (ADL_13).

In addition to cognitive proximity in terms of related similar and diverse scientific knowledge, many firms categorized as strong and moderate knowledge seekers highlighted the need to access sophisticated scientific technical equipment that contributes to the firms’ R&D and technology development activities: *“It is extremely important for a company like [company name] to have access to institutes that have got very specialized equipment.” (ADL_17).* Since many of the firms are micro and small businesses the accessibility of certain scientific infrastructure is also related to cost savings. It also applies to the testing and validating of the SMEs’ new technologies and product prototypes. Moreover, the cooperation with related academic institutions in this respect also increases the firms’ reputation and, thus, the marketability of new products, for example, through scientifically verified testings of new products and technologies: *“We want the scientific background being proved. (...) There we want to be able to say we have tested this device there and there, and that’s why it’s good.” (ADL_19).*

Furthermore, the prominent function of cognitive proximity within the proximity configuration in knowledge relations to scientific institutions is also illustrated in relation to other dimensions of proximity. To begin with, the companies emphasized that when they look to access specific scientific knowledge, appropriate knowledge sources are approached. Whether prior shared work or personal experiences exist or not rather is a subordinate concern: *“When we have to realize a specific task. What we do first is to look in the Internet or in the contact list that we have. When we find the person or the research group that can resolve the problem (...), I immediately send them an email.” (CAR_22).* Also geographical proximity to scientific partners is not considered as a decisive criterion. This is also reflected in the high importance of non-local knowledge relations to academia throughout the three different types of STP resident firms (see Chapter 4.3). One interviewee interpreted the relevance of fitting scientific knowledge in relation to social and geographical proximity: *“I’m looking for the one that has the highest competency. Usually, that’s not the one who works next to me. (...) Also, personal aspects are not the crucial factor.” (ADL_16).* Thus, consistent with the findings of Mattes (2012), also the STP resident firms’ knowledge relations to academia always imply an intention to interact, to share and to acquire certain knowledge.

In sum, cognitive proximity takes over an exceptional role in the proximity framework in knowledge relations between STP resident firms and academia. Furthermore, the qualitative analysis confirms the emphasis widely stated in the literature that sufficient cognitive proximity is a necessary prerequisite for successful knowledge interaction to take place.

4.5.2 Critical need for sufficient institutional similarity

Institutional proximity, defined as a shared institutional framework in terms of formal (e.g. rules, laws, and regulations) and informal institutions (e.g. norms, values, customs, codes of conduct) reducing transaction costs and uncertainty, is assigned a critical enabling role in the creation and realization of knowledge linkages (Boschma, 2005; Mattes, 2012). In particular in industry-academia knowledge relations normally strong institutional discrepancies are observed (see Chapter 2.3.2). Firstly, scientific research, in particular basic research, differs significantly from industrial technological development oriented to the market. Secondly, the objectives and incentive structures of academia and the private sector vary strongly. Thirdly, differences in the organizational culture, for instance, concerning methods of problem solving and time constraints, also are common obstacles of effective interaction between the two worlds (Ponds et al., 2007).

In knowledge relations to academia, the reduction or compensation of usually too large institutional distance also is identified as a fundamental challenge that the STP resident firms interviewed have to cope with. Strongly linked to the previously discussed cognitive proximity, the companies aim to develop new technologies, products and services to be sold on the market. In contrast, scientific institutions do not necessarily focus on market-oriented research activities or, in other words, the scientific knowledge often does not cater to the firms' market-oriented technological development. One firm underlined this aspect: *"We want to develop things that we can sell at the end. That's not always the case in scientific institutions. There're always discrepancies."* (ADL_7).²¹² Thus, the interviewees thoroughly demanded that knowledge relations to scientific actors must add to the development of marketable products and technologies in the short or medium-term: *"At least, it must result in something marketable in the medium-term. This always is the priority. Either a completely developed innovative product or a technology, which can be licensed."* (ADL_12). Strongly linked to the varying overall objectives of businesses and academia, the interviewees also underscored the different incentive structures as a major obstacle for successful link creation and realization of interactive ties with researchers: *"Scientific entities are interested in publications, patents, etc. And companies are interested in markets and economic benefits. (...) This makes real cooperation really hard."* (CAR_2).

²¹² In a more detailed statement, one interviewee illustrated the strongly diverging character between academic research and firms' technological development: *"I know how they work and the quality of their work. At the end, it's useless. (...) It's not their goal to market technology. I know scientists that have completed a project and put into the drawer: What's the next project?"* (ADL_8).

Furthermore, the interviews reaffirmed that normally severely varying work cultures in businesses and scientific institution, for example, in regard to methods of problem-solving and understanding of deadlines, hamper productive interaction to a significant extent: *“What happens it that the university is a very rigid element, which takes a lot to understand the concepts of a private company (...) regarding limited time, fixed deadlines and that you have to generate a certain profit and that you have to control the expenditures. (...) Sometimes it’s like the university and the company don’t speak the same language.”* (CAR_16). As the companies interviewed primarily serve to other industrial clients, relevant business standards are also applied towards their academic partners. Thus, in regard to a shared organizational culture, especially the importance of reliability, capability and the ability to deliver, as well as budget and time constraints were emphasized as important criteria for starting collaborative projects with academics: *“In addition to the technical criteria, whether they can fulfil them, whether they fit in generally – based on contractor’s references such as timeliness. (...). There’re additional parameters, for example, deliverability, quality and performance.”* (ADL_9).²¹³

Yet, the knowledge relations with local and non-local academia of the companies examined at the Adlershof and Cartuja science parks showed two different coping approaches to the barrier of institutional discrepancies. Firstly, many of the STP resident firms maintain knowledge relations to technically oriented universities (including technical universities overall and universities of applied sciences in Germany in specifically) and applied R&D institutions like of the German Fraunhofer Society in particular (see Chapter 4.2). Thus, it indicates that the focus of respective universities and research institutions on applied and engineering-related research coincides more strongly with the firms’ focus on technological development, market-oriented outcomes and business-oriented work routines. In this regard, an interviewee from the Adlershof science park highlighted, for example, universities of applied sciences as less institutionally distant compared to other types of universities: *“The classical universities have another focus than universities of applied sciences. For us, universities of applied sciences sometimes are the better partners, because they are more practical-oriented.”* (ADL_17).²¹⁴ Also, Ponds et al. (2007) have emphasized that there is a higher institutional distance for businesses to research institutions that focus on basic research vis-à-vis applied research institutions.

²¹³ In addition, another interviewee’ statement demonstrates the need for common work routines and norms: *“We expect this kind of professionalism; how much time they have worked on it, finishing the tasks on time.”* (CAR_26).

²¹⁴ Also another firm differentiated between different scientific actors’ capability to adapt to businesses’ work standards: *“They are many persons that understand how a business works. They know about your problems, deadlines etc. (...) Other [research] groups lack this kind of understanding.”* (CAR_12).

Secondly, a large number of interviewees pointed to the enhanced likelihood to harmonize normally differing norms and work routines due to shared work experiences and cooperation projects, respectively, in the past: *“We don’t ask a technology centre without being on the same page in terms of the ideas and objectives. (...) Let’s say, we use the relationships that we already have established well in order to know what is going on. We select the partners that we feel comfortable with.”* (CAR_20). This corresponds to findings of Kujath (2008) underlining that repeated interaction and first collaborations can result in the development of mutual values and routines. Also, it is consistent with scholarship (Thune, 2009; Balland et al., 2012) that has argued that social proximity can compensate too much institutional distance in the creation and realization of knowledge ties due to their similar roles as enabling factors.²¹⁵

At large, adequate institutional proximity is considered a critical need for the initiation and successful realization of industry-academia knowledge relations in particular. Shared objectives, work cultures and understanding regarding market environments are important criteria for the Adlershof and Cartuja-based firms to ensure the effectiveness of knowledge relations to academia. The firms’ preference for interactive ties to technical universities and applied research institutions that feature a certain market-orientation and focus on application-oriented technology development illustrates this point. Furthermore, enhanced social proximity due to prior shared experiences between a firm and scientific institutions can increase the likelihood to identify shared objectives and surrounding conditions of collaboration despite normally strong institutional distance.

4.5.3 Social proximity is a key enabling factor of interactive ties to science

Socially embedded relations based on shared personal and work experiences, among others, are considered as critical or auxiliary enabling factors for the creation and realization of knowledge relations. Closely related to social proximity shared trust between actors strongly facilitates the open exchange of knowledge, in particular tacit knowledge that is eminent to innovation (Boschma, 2005).

²¹⁵ Also Huber (2009) has stated that strong social embeddedness in terms of emotional closeness and feelings of personal obligation facilitates the identification of shared objectives despite normally rather strong institutional dissimilarities.

As I have specified in Chapter 4.4.1, a great majority of the firms pointed out that a large amount of linkages to research institutions originate from personal relationships.²¹⁶ In particular, contacts to former fellow students and co-workers, as well as prior business relations are fundamental influencing factors for the creation and realization of knowledge relations with academia in the STP and external to the STP. As an illustration of the former, multiple Adlershof-based interviewees underscored their studies and/or research positions held in the past at the HU-Berlin or other research institutions such as the DLR and FBH for the formation of local interactive relations: *“I still have very close links to the HU-Berlin, because I worked there.”* (ADL_16). Similarly, several firms highlighted the personal ties to former colleagues of the Academy of Science of the GDR, who now work a diverse businesses and scientific institutions in the science park.²¹⁷ This corresponds to the results of previous empirical studies in the Adlershof science park (Brühöfener McCourt, 2009; Jähneke, 2009). In regard to the STP Cartuja, many of the resident companies’ ties to scientific institutions can be traced back to shared studies and work experiences at the School of Engineering of the University of Seville in particular. In particular the academic spin-offs interviewed strongly benefit from the existing ties to their - mostly co-located - scientific parent organizations and contacts to other scientific actors developed in the past in the realization of current multi-faceted knowledge relations: *“Clearly, with [names of the Cartuja-based scientific parent organizations], it’s due to the founders of the company, their personal connections. With the institutions outside the science park, the relationships are also based on personal connections. (...) When there was a R&D project in the field that we work in, right away, they know another university.”* (CAR_15).

For the latter, personal relationships strongly enable the development and retention of knowledge relations with regional, national and international scientific institutions, too. One interviewee from the STP Cartuja revealed the firm’s geographically dispersed knowledge relations to academia that were formed thanks to socially embedded linkages to its personnel: *“Because the research groups that we have contacted or identified are partly fellow students and acquaintances of our employees. (...) We have a lot of employees that have studied at the School of Engineering [author’s note: of the University of Seville]. (...) And this is also because some of our colleagues have worked first at the Technological Institute*

²¹⁶ As discussed in Chapter 4.4.1, about 77% of the 52 companies stressed the importance of their social networks for linkages to scientific actors. While ca. 95% of strong knowledge seekers and all firms classified as moderate knowledge seekers placed emphasis on this entry channel, ca. 54% of lame knowledge seekers stressed this point.

²¹⁷ One interviewee illustrated the important role of personal relationships to former work colleagues at AdW: *“Many of these relationships are based on personal contacts, in particular to former colleagues at the Academy of Sciences [of the former GDR] that work at Humboldt-Universität zu Berlin or at research institutions now.”* (ADL_2).

in Aragon." (CAR_11). These findings correspond to the existing academic literature that has underlined the ability of knowledge interaction between geographically distant actors due to strong socially embedded ties (Agrawal et al., 2006). Overall, also Thune (2009) has emphasized personal trust-based relations as primary entry channels for inter-organizational R&D cooperation.

In addition, but rather rarely, existing or prior business relationships with academic actors linked have resulted in the formation of ties geared towards collective knowledge creation.²¹⁸ In a few cases, the businesses also take advantage of the mobility of their socially embedded ties, thus enabling the development of new knowledge relations to additional scientific institutions in vicinity or far away over time. An interviewee from the STP Adlershof illustrated this point: *"One of my former colleagues at the [name of Adlershof-based R&D institute] is a professor there [author's note: a Berlin-based university] now, and therefore, we have a good connection there."* (ADL_4).

Furthermore, in some cases, existing relations to trusted scientific actors served as a reliable source of trustworthiness and reputation to allow the development of new interactive ties to previously unconnected scientific institutions and researchers, respectively. One interviewee pointed to an exemplary case: *"[Our linkages] to the professors [names of two HU-Berlin professors], this was done by [name of the professor of the firm's academic parent organization]. I asked him to make a contact to them, and then I took the initiative to have a first meeting."* (ADL_26). Especially in the case of STP resident firms identified as strong knowledge seekers, the comparatively greater importance of direct inquiries by scientific institutions for collaborative activities is related to strong structural embeddedness in communities of practice and associated networked reputation: *"The contacts originate from the community. I know the [research] groups and we approach them directly, or they approach us."* (ADL_21). Nooteboom (2000a) as well as Glückler and Armbruster (2003), among others, have stressed the transfer of trustworthiness in newly created interactive relations.

Overall, the socially embedded knowledge relations of the firms to academia are characterized by trust, which increases the likelihood for an open exchange of tacit knowledge instead of calculative behaviour, as also Breschi and Lissoni (2003) have pointed out. One interviewee underlined the fundamental significance of shared trust for

²¹⁸ For example, this Adlershof-based company highlighted the role of existing business contacts as a starting point for joint R&D projects: *"Many of the relationships are based on personal contacts and business contacts, respectively, which enable the creation of joint research projects. The personal contact and trust has been created before."* (ADL_3).

knowledge interaction: *“Trust is necessary, the personal contact. That’s crucial for the exchange of information.”* (ADL_6). In addition to increased trust over time, repeated shared experiences and interaction result in enhanced cognitive understanding, too. Thus, stable and long-term relations, termed strong ties by Granovetter (1973), are developed, as one interviewee highlighted: *“Basically, we always work with the same universities, departments and research centres (...). When we worked with a [research] group, it’s easier to collaborate again.”* (CAR_14). This positive correlation between social and cognitive proximity, also emphasized by Boschma (2005) and Broekel (2015), applies to academic spin-offs in particular.²¹⁹

In stark contrast, the lack of personal relations to science represents a two-folded disadvantage to some of the STP resident firms examined, which are mostly categorized as lame knowledges seekers. Firstly, without personal contacts and prior cooperation the firms lack entry points to access specific scientific knowledge and resources. Secondly, these firms also lack sufficient information about relevant research activities that could set the potential for interactive relations. An Adlershof resident company stated this aspect as a great obstacle hampering the likelihood to develop relations to academia: *“We just don’t have the contacts there and the knowledge about the existing [research] institutions.”* (ADL_5).

To sum up, the firms’ social networks due to shared personal, work or business experiences are very critical enabling factors for the formation of local and extra-local knowledge relations to academia and related knowledge sharing activities. Most importantly, associated trust increases the likelihood for the exchange of complex, and sometimes confidential, tacit and explicit knowledge. Furthermore, repeated interaction in conjunction with social proximity increases cognitive proximity and, in turn, reinforces the likelihood for effective knowledge interaction and learning.

4.5.4 Organizational proximity as another critical criteria to reduce uncertainty

In the academic discussion, organizational proximity, which refers the degree of actors’ affiliation or belonging to organizational arrangements, is assigned a critical enabling func-

²¹⁹ One company elaborated on this relationship: *“At the beginning, I collaborated with research groups where I worked as a researcher before. (...) Because of the relationships I had with them, the research activities were quite similar, we had things in common.”* (CAR_12).

tion in knowledge relations. While market ties are allocated with low organizational proximity, loosely-tied industry networks and company joint ventures relate to a medium-level of organizational proximity. Multi-unit companies or strongly hierarchically organized networks are characterized by a high level of organizational proximity. Varying levels of autonomy and linked exerted control mechanisms serve to reduce uncertainty and risks of opportunism. This facilitates successful knowledge interaction and, in turn, sets potential for interactive learning and new knowledge creation (Boschma, 2005).

In the STP resident firms' relations to scientific institutions, multiple organizational arrangements can be observed. On the one hand, the interviewees stressed bilateral or multilateral organizational arrangements such as contractual agreements (e.g. contract research, joint research projects and licensing) and, in the case of academic spin-offs, organizational affiliations to scientific parent organizations. On the other hand, publicly subsidized and coordinated industry-academia R&D project consortia and professional networks, among others, represent external organizational structures that are related to specific KNM instruments. This sub-chapter explicitly discusses the relevance of the former.²²⁰

Thereafter, many interviewees highlighted formalized cooperation with scientific institutions, in which formal contracts and agreements serve as a basis for trusted collaboration. Similarly to joint ventures, formalized partnerships can be linked to a medium level of organizational proximity. In this sense, contracts and agreements clarify objectives and content of the cooperation, the framework conditions and partners' responsibilities, as well as related rules regarding the ownership and confidentiality of knowledge, among others. Thus, it was pointed out that contracts and distinct non-disclosure agreements typically provide sufficient certainty for the effective and open sharing of knowledge in proven and newly created partnerships: *"We subcontract the university, for example. (...) We sign an agreement beforehand, in which we define the framework conditions, responsibilities and the copyrights of the intellectual property. We have to define who will own what."* (CAR_11). Also Dettmann & Brenner (2010) have emphasized that shared formal rules, roles and structures enable the formation of new knowledge relations in particular, as they reduce uncertainty, lower entry barriers for new partners, increase the controllability of first joint activities and define realistic expectations.

²²⁰ The underlying mechanisms of external organizational arrangements related to KNM, such as formal networks and publicly coordinated R&D projects, are discussed in Chapter 4.6.

In addition, the interviewees emphasized that contractually defined framework conditions, partners' responsibilities and milestones, among others, also contribute to a shared understanding of work procedures and objectives. A company showcased the needed clear definition of common work routines and objectives based on contractual agreements in contract research: *"So, what we expect is that the tasks that have been out-sourced or sub-contracted, i.e. the R&D part that is more original, which they are more capable to do, are realized and also in the time period that we have defined in the contract. Basically, our demand is that they do what they have proposed and defined based on the contract."* (CAR_15). Thus, a certain degree of organizational proximity associated with contract-based control mechanisms can reduce traditionally given strong institutional discrepancies between industry and academia. Also Balland et al. (2015) have stressed this compensatory function due to the similar roles of organizational and institutional proximity as enabling factors in knowledge relations.

Similarly, the interactive relations of many spin-off firms examined and their scientific parent organizations are often defined by contractual agreements, too. In addition to strong personal relationships to former work colleagues, the large majority of the spin-offs dispose of general agreements with their former university departments or research groups that clearly specify the scope and diverse modes of cooperation. As an illustration, one Cartuja-based university spin-off company described the organizational relationship to the University of Seville in this way: *"We have needed access to laboratories and we have a general agreement with the School of Engineering of the University of Seville in order to use their laboratories and their system."* (CAR_19). Thus, the large majority of the university and R&D spin-offs underlined enhanced trust and certainty due to the combination of social proximity, as outlined before, and organizational relatedness in their knowledge relations to the scientific parent organizations in particular.

Altogether, organizational proximity is another critical enabling factor for many of the firms' knowledge relations to science in addition to social proximity. Similarly to social proximity, organizational proximity reduces uncertainty and, in turn, facilitates link creation and increases the likelihood for productive knowledge interaction.

4.5.5 Geographical proximity as enabling criteria for local buzz and the creation of more fundamental types of proximity

According to the recent academic discussion, geographical proximity has two functions in knowledge relations. Firstly, spatial agglomerations of knowledge organizations typically

create buzz, i.e. the constant and informal flow of information, and, consequently, increase the likelihood for unintended knowledge spillovers (Bathelt et al., 2004). Secondly and also more importantly, geographical proximity in conjunction with enhanced opportunities for repeated personal interaction primarily facilitates the development of other natures of proximity that are perceived more critical for knowledge interaction. This refers to cognitive, social and institutional proximity in particular. Thus, geographical proximity is predominantly regarded as an auxiliary parameter, which must be supplemented by other forms of proximity, in knowledge relations (Boschma, 2005).

The identification of, on the one hand, the strong importance of non-local knowledge relations to academia overall and, on the other hand, strong multi-faceted or only very selective interaction with co-located scientific actors have already pointed to a varying significance of geographical proximity in the firms' linkages to science (see Chapters 4.2 and 4.3). The qualitative interviews also predominantly confirmed this versatile role of geographical proximity in the STP resident firms' knowledge relations to academia.

Multiple STP resident firms articulated the importance of local buzz based on the spatial agglomeration of similar and complementary technology-oriented firms and scientific institutions at the STP. As one company stated: *"There is no better environment for stimulating mutual cooperation between companies and research centres."* (CAR_5). In particular, the STPs' third places, for example, cafés, restaurants and other meeting places (see Figure 39), were indicated to have an important role in facilitating informal interaction: *"At the lunch together or running into each other in the kitchenette, sometimes you can observe the most amazing flows of information. You work on something, and somebody has heard something about it, and throws it in."* (ADL_25). This refers to the so-called cafeteria effect coined by Camagni (1991), which underlines the increased likelihood of intended and unintended face-to-face interaction and, in turn, knowledge spillovers between diverse actors due to geographical co-location.²²¹

²²¹ Also Balland et al. (2015) have underlined that geographical proximity still is regarded to positively affect the creation of knowledge linkages, despite the more crucial function of non-spatial proximities in this respect.

Figure 39: Café at the Adlershof science park



Source: Author

In addition to - often unintended - knowledge spillovers and learning due to facilitated personal encounters and social interaction in the STPs, various interviewees, especially in the two groups of strong and moderate knowledge seekers, also pointed to the importance of geographical proximity for the formation and realization of rationally planned and strategically important knowledge relations (strong ties) to distinct institutions with fitting scientific expertise and infrastructure located at the STPs (see also Chapter 4.2).²²² In this regard, the selected interviewees placed emphasis on augmented opportunities for spontaneous and frequent face-to-face meetings to facilitate the effective sharing of complex and tacit knowledge in, for example, joint R&D projects: *“The spatial proximity to the [name of a R&D institution] is imperative. We wouldn’t be able to do this via phone or email. (...) There’re regular meetings, but also very demand-specific meetings, for example, on the working level where their employees pass on something about standard material that we obtain, or between the developers on R&D projects (...)”* (ADL_9). Similarly, the physical co-location allows another company at the STP Cartuja to implement a joint co-working

²²² As an illustration, one interviewee named several co-located scientific institutions as fundamental scientific knowledge sources: *“The fact of being at the STP Cartuja (...) allows us many synergies with other entities that are also located at the STP Cartuja that focus on new and advanced medical techniques, and are strongly related to the paradigm of molecular and personalized medicine. (...) The co-located University of Seville, the National Accelerators Center (...). It’s the only Spanish research centre [in this field] and it’s located at the STP Cartuja.”* (CAR_21).

setting for an industry-academia R&D partnership in order to enable constant face-to-face interaction and, in turn, effective exchange of knowledge: “(...) *in the following collaborations, we have used mixed teams from the university and us. (...) They worked together in our offices. (...) That’s why we have to be here.*” (CAR_23). Both exemplary cases illustrate the facilitative role of geographical proximity to reduce transaction costs and to enable the sharing of tacit knowledge through face-to-face interaction, as it is widely discussed in the various concepts of industrial clusterings and TIS. Similarly, multiple resident companies underlined the quick access to specialized scientific equipment due to the immediate vicinity of strategically important academic partner institutions at the STP: “*For that matter, spatial proximity is important, especially to the [name of a R&D institution], because we have some equipment in a clean room there. It operates there in a very professional clean room environment. (...) Such close cooperation only is possible due to spatial proximity. Other cooperation relations are not as dependent.*” (ADL_19). Furthermore, individual spin-off entrepreneurs stressed the convenience of geographical proximity, which allows them to manage parallel research positions at co-located universities or R&D institutions. One interviewee pointed this aspect out: “*We have both institutes here in a range of five minutes, which facilitates it a lot. (...) This way the partners can work at the university and at the company at the same time.*” (CAR_15).

Nevertheless, the great majority of the STP resident firms’ egocentric knowledge networks to academia are not limited to the STPs. Instead they reaffirm the notion of the multi-scalar process of knowledge sourcing and knowledge interaction emphasized by Tödtling and Trippi (2015), among many scholars. Many firms even highlighted the higher importance of multi-faceted non-local knowledge relations vis-à-vis local interaction with scientific institutions (see Chapters 4.2 and 4.3).²²³ As I have described earlier, the companies interviewed consider other types of proximity more critical for the formation and realization of interactive linkages to academia. One interviewee illustrated this overall finding: “*In order to interact positively it’s not important whether our partners are located in the STP Cartuja, or not.*” (CAR_20). An additional statement made illustrates that knowledge relations to scientific actors are not determined by co-location, but are essentially defined by the a firm’s knowledge demands, as well as some form of trust or certainty: “*We know how to do some things, but some things we don’t know how to do them. (...) We know some people that can resolve the problem. When not here than somewhere else, it can also be in Pamplona, Madrid or I don’t know where.*” (CAR_22).

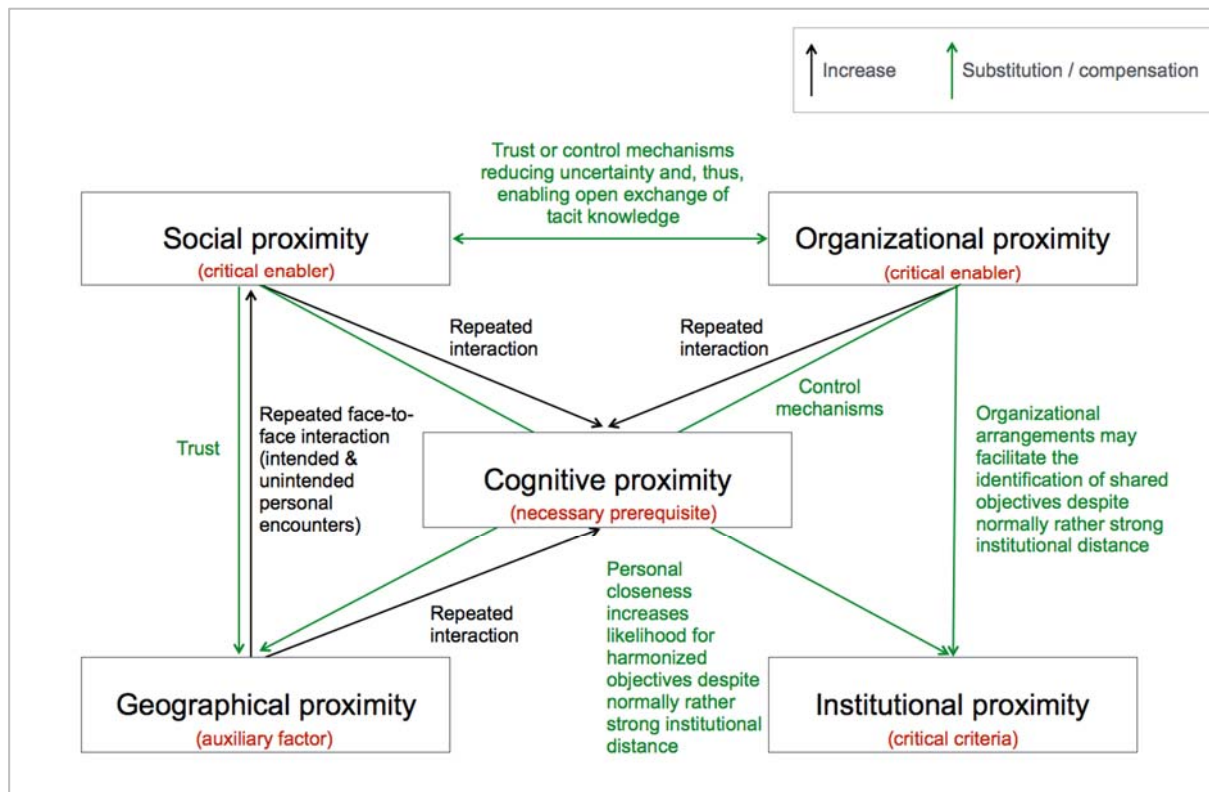
²²³ Consequently, to some extent, the findings contradict other studies (e.g. Jaffe et al., 1993; Audretsch & Feldman, 1996) that confine knowledge externalities to geographical proximity.

In sum, co-location in the STPs drives the development of buzz and, in individual cases, facilitates multi-faceted knowledge interaction to co-located scientific institutions, which are crucial suppliers of fitting knowledge and infrastructure. However, it does so by primarily enabling repeated personal interaction and, consequently, the development of other non-spatial types of proximity (e.g. cognitive and social proximity) that have been identified as necessary and critical criteria for successful link creation and knowledge interaction with academia. In addition, the great majority of the STP resident firms assigns a strong or even higher value to interactive ties to non-local academia, which is only explained by the independent work of non-spatial proximities, especially social and organizational proximity. Consequently, geographical proximity predominantly takes over an auxiliary factor in the knowledge relations between STP resident companies and academia overall.

Box 11: Preliminary summary of relevant proximity configurations

In sum, the qualitative findings in regard to the proximity framework in STP resident firms' knowledge relations with academia coincide to a large extent with the specific functions of the different types of proximity and the relationships to each other underlined in the academic discussion. Yet, I have detected some peculiarities in the specific case of cross-institutional knowledge relations examined. Figure 40 illustrates the identified specific roles and interrelations of multi-faceted proximity in the cross-institutional knowledge relations examined.

Figure 40: **Proximity framework in STP resident firms' linkages with academia**



Source: Author

Thereafter, sufficient cognitive proximity, i.e. the overlap of knowledge bases, has an outstanding importance in knowledge interaction with academia in general. Typically, the businesses examined seek access to very specialized scientific knowledge and resources. Whether scientific institutions are capable to meet the specialized knowledge demands of the STP resident companies primarily determines the effectiveness of interactive knowledge relations. Thus, cognitive proximity is highlighted as necessary prerequisite for successful industry-academia knowledge interaction. Based on a firm's distinct knowledge demands, the degree of knowledge diversity may vary in order to enable the access and absorption of complementary or more novel scientific knowledge. In general, cognitive

proximity between businesses and scientific institutions can increase through repeated interaction, which is facilitated by other types of proximity considered. However, too large cognitive distance cannot be substituted by other proximities.

Furthermore, sufficient institutional similarity is a critical issue in knowledge relations between companies and scientific actors overall. Shared objectives and work cultures are important criteria for the Adlershof and Cartuja-based businesses to ensure productive interaction with academia, for example, in terms of marketable outcomes as a result of joint research projects. As a consequence, the STP resident companies examined tend to rely more strongly on linkages to technically as well as application-oriented universities and research institutions. Furthermore, personal relationships and organizational arrangements facilitate the identification of mutual objectives, norms and routines despite normally strong institutional discrepancies between companies and scientific institutions.

Social and organizational proximity in conjunction with trust and reduced uncertainty are critical enabling factors for link creation and knowledge sharing between STP resident firms and scientific actors located in the STP and external to the STP. For the former, especially shared personal, work, business and study experiences, but also networked reputation strongly affect the likelihood of successful knowledge interaction. In contrast, businesses without any socially embedded linkages generally face difficulties identifying and accessing fitting scientific knowledge sources. For the latter, in particular formal agreements related to control mechanisms and fixed rules of conduct strongly facilitate cooperation with formerly unconnected scientific knowledge sources, but also with already proven academic partners. In this regard, organizational proximity amplifies trust already established in socially embedded relations. Due to their similar roles as enabling factors reducing uncertainty and, consequently, permitting the open exchange of, sometimes confidential, tacit and explicit knowledge, social and organizational proximity can substitute each other.

Ultimately, geographical proximity primarily takes over an indirect function in knowledge relations. In this sense, it helps develop more critical types of non-spatial proximity, namely cognitive and social proximity, by creating enhanced opportunities of face-to-face interaction. Nevertheless, physical co-location is still found to positively affect knowledge linkages between resident firms and co-located science in the STPs. This applies to the important role of local buzz in the STPs and the facilitation of rationally intended interaction with selected strategic scientific partner institutions. However, non-local knowledge relations to academia, in particular regional, national and European pipelines, are of great or even greater importance to the STP resident firms. In these cases, successful knowledge interaction is primarily induced by the independent functionality of non-spatial types of proximity, in particular cognitive, social and organizational connectedness.

Also in relation to the organization of specific proximity configurations I analyse the underlying mechanisms of specific KNM instruments in Chapter 4.6.

4.6 Organization of proximity by knowledge network management

In this chapter, I analyse in more detail the underlying mechanisms of KNM instruments as important enabling channels and platforms for the formation and realization of industry-academia knowledge relations. In addition to the quantitative analysis of analogue KNM tools at the Adlershof and Cartuja science parks (see Chapter 4.4), the qualitative analysis intends to explore to what extent knowledge network management organizes specific proximity configurations in order to facilitate link creation and knowledge sharing successfully (**research question 5**). Next, I discuss the organization of specific types of proximity, identified as necessary, critical or auxiliary criteria in knowledge relations, by design for the following KNM instruments:

- Public support schemes for industry-academia R&D projects,
- Local technology networks,
- Local networking events and locally organized conferences,
- Intermediaries,
- STP-related knowledge marketing.

The findings of this explorative analysis aim to contribute to the formulation of specific policy recommendations on how STPs can design and orchestrate KNM systems to promote industry-academia knowledge relations effectively.

4.6.1 Coordinated R&D programmes as trust-compensating external structures

In the quantitative analysis public support schemes providing for industry-academia R&D projects have been identified as the most important KNM instrument assisting the STP resident firms' in forming and carrying out knowledge relations with academia.²²⁴ Due to their

²²⁴ Almost 86% of the firms specified as strong knowledge seekers (n=21) evaluated the importance of public support schemes for industry-academia R&D projects strongly. Also, about 67% of the 18 firms in the group of moderate knowledge seekers underlined their significance, whereas only a fraction of ca. 31% in the group of lame knowledge seekers regarded them as very important or important (see Chapter 4.4.1).

geographical alignment on the extra-local scale (i.e. regional, national and European scale), such programmes primarily promote non-local knowledge relations.

To begin with, public support schemes typically define the specialization of the industry-academia R&D projects in terms of industry and technology area, respectively. As a consequence, a sufficient cognitive relatedness of the project consortia is ensured. Depending on the R&D projects' focus, a project consortium of businesses (mostly SMEs) and scientific institutions, which possess specialized similar or complementary knowledge, is formed. Based on the geographical alignment of the specific public support programme, it comprises a broad range of regional, national or European knowledge organizations. An interviewee described the composition of such publicly subsidized project consortia based on specific technological and scientific expertise: *"Mostly, the Wachstumskerne [author: name of a public support scheme in Germany] and Förderverbünde [i.e. consortia of organizations] are project calls of the BMBF, which tender specific topics. (...) The application-oriented actors get together in the consortia. For example, an industrial partner that wants to build lasers for welding. He thinks about the technology needed and looks for [academic] partners to complete the research project successfully."* (ADL_9). As a result, the organized cognitive proximity within such industry-academia R&D project consortia does enable effective communication and sets the potential for the successful exchange and combination of know-how in order to generate innovative outcomes. In this sense, the necessary prerequisite for knowledge interaction and, in turn, interactive learning between firms and academia is fulfilled.²²⁵

Furthermore, to obtain productive outcomes public support programmes apply structuring and coordination mechanisms. These governance mechanisms serve two purposes. Firstly, they help to compensate for often lacking social proximity and trust among mostly previously unconnected project partners. Secondly, they define shared objectives and framework conditions despite normally strong institutional dissimilarities between participating firms and scientific institutions.²²⁶ Regarding the former, the interviewees underlined an appointed project leader and a certain hierarchy, as well as exerted control mechanisms that reduce uncertainty and risks of opportunistic behaviour in knowledge sharing. In par-

²²⁵ Publicly subsidized industry-science R&D projects are structurally designed based on technology foresight, tenders, peer review-based selections and specific compositions of project consortia, for example, specific types of academia and firms. Moreover, by specifying the thematic alignment, governments try to ascertain that the public investments will result in the expected outcomes in terms of innovative technological developments (Czarnitzki et al., 2007; Grimaldi & von Tunzelmann, 2002).

²²⁶ Czarnitzki et al. (2007) have highlighted that public authorities or project management agencies usually carry out the administration of such funding programmes. Overall, beneficial effects of publicly coordinated industry-academia R&D projects comprise positive knowledge spillovers, R&D subsidies, governance structures, as well as cost and risk sharing.

ticular, the ownership of intellectual property and the confidential treatment of project partners' knowledge are of special importance and clarified beforehand: *"The Charité is the project coordinator, and there's a specific project procedure. (...) At these projects, we always sign a NDA. (...) There's also a cooperation agreement that defines how to deal with new results and patents. (...) I never had any objections. We always have an open exchange of thoughts and ideas."* (ADL_10). Thus, the organization of a medium degree of organizational proximity in publicly coordinated R&D projects takes over a critical enabling role, as it facilitates the formation of industry-academia consortia, often linked to new knowledge relations among formerly unconnected actors, and the open exchange of knowledge during the course of the temporary cooperation. In other words, it substitutes for the lack of social proximity, thus, enabling the access to new, potentially more diverse knowledge that sets potential for learning. This coincides with the findings in Chapter 4.5 that have also pointed to the critical enabling role of organizational proximity in knowledge relations and its compensatory function for too much social distance.

Regarding the latter, the interviewees emphasized that the formally defined framework conditions in publicly coordinated R&D projects help to identify shared objectives and work procedures. This relates to clearly defined responsibilities and milestones, for example, in regard to intermediate and final deliverables for each project partner. One interviewee illustrated this point: *"All the R&D projects include a general contract, and there're special contracts with [name of the company] and the specific university. In this contract, the work, the amount of time the university will work on it and the economic conditions are specified. (...) Everything is based on contracts. Everything is regulated."* (CAR_15).²²⁷ Thus, organizational proximity in terms of strict governance mechanisms can bridge or reduce traditionally strong institutional discrepancies between industry and academia.²²⁸ Balland et al. (2015) have also pointed out this compensatory mechanism.

In addition, the governance frameworks of such supra-local R&D projects also constitute specific communication regimes in order to ensure the effective exchange, combination and internalization of knowledge among project partners over distance. The interviewees underscored temporary meetings as important integrated communication elements, which

²²⁷ Another interviewee underlined the important role of strictly specified responsibilities and effective communication to generate productive outcomes in publicly subsidized cross-institutional R&D programmes: *"Everybody has its own project part. There're different work packages, which are executed by each project partner independently, but when you meet and coordinate regularly so that the interfaces are defined. And this works pretty well."* (ADL_26).

²²⁸ In regard to the observed enabling role of organizational proximity demonstrated here and in Chapter 4.5.4, Nambisan and Sawhney (2011) have pointed out that formal contracts take over the role of leveraging "the structural embeddedness in the network to minimize undue appropriation of value without sacrificing the intensity of knowledge sharing" (Nambisan and Sawhney, 2011: 52) in inter-firm innovation projects.

facilitate personal interaction and, consequently, the creation of a shared understanding and the effective exchange of knowledge: *“In terms of working in these kinds of cooperation projects, in most of the cases some really good work can be done with somebody that is situated in Seville and another one that is located in Norway. (...) There’s a system of mediums to maintain this relationship, to do this collaboration as easy as possible.”* (CAR_24).²²⁹ On the one hand, this finding reaffirms the notion that organizational proximity is a crucial factor in order to enable knowledge interaction over spatial distance, as multiple scholars have stressed (e.g. Knobon & Oerlemans, 2006; Lagendijk & Lorentzen, 2007). On the other hand, it implies that temporary co-presence, for example, in scheduled personal meetings, in combination with ICT-based communication technologies (virtual buzz), can substitute for the need for permanent spatial proximity in knowledge relations. Kujath (2008) and Bathelt and Turi (2011), among others, have also underlined this aspect.

Finally, many interviewees emphasized that first mutual work experiences and repeated (personal) interaction within such externally coordinated project consortia also encouraged the development of personal relationships and increased multi-dimensional trust (i.e. competence and goodwill trust) to scientific project partners. In some cases, newly created weak ties evolved to strong ties over time: *“In other cases, the partnership are established by coincidence through projects that involve multiple partners. Out of this, stable relations can evolve. Stable links are created based on first successful cooperation. When there wasn’t an effective cooperation, there won’t be a next mutual project.”* (ADL_4). Among others, Mattes (2012) has underlined the positive correlation between organizational proximity and social as well as cognitive closeness.²³⁰

In sum, the strong influence of public support schemes on STP resident firms’ creating and carrying out successful knowledge relations to academia, especially over geographical distance, is predominantly determined by the combined organization of necessary and critical types of proximity: 1) sufficient cognitive overlap, 2) organizational closeness associated

²²⁹ According to Harmaakorpi & Melkas (2005), typical formats of interaction and communication in formal cooperation projects include personal meetings, phone conferences, virtual forums, good practice reports and on-site visits, among others. To illustrate, one interviewee explained the different channels of communication: *“We have a vivid communication; meetings, phone calls and documentations. We transfer information using documents in the way that we define what we really want and what we are expecting specifically.”* (CAR_9). Grabher and Maintz (2006) have stressed that virtual networking forums and software may enhance the scope and the strategic use of professional contacts. Both personal and virtual interaction can complement each other. However, face-to-face interaction still is more critical to build up reliable and trustful relationships.

²³⁰ Mattes (2012) has stated that social proximity is strongly interrelated with all other proximities considered, as “it is encouraged by them, occurring as a side-effect and as a result of proximities in the other dimensions” (Mattes, 2012: 1090). Kujath (2008) has highlighted that stronger organizational settings facilitate the reduction of cognitive distance due to more frequent communication and interaction.

with reduced uncertainty and 3) adequate institutional similarity. In addition, the rather indirect influence of temporary geographical proximity on augmented cognitive and social proximity is exploited systematically. Thus, this combined set of proximity not only facilitates non-local knowledge interaction, but also the formation of new linkages to scientific knowledge sources in particular. In addition, first mutual cooperation projects reinforce the likelihood and ability for follow-up interaction by increasing cognitive and social proximity. Consequently, publicly coordinated industry-academia R&D programmes can be labelled as trust-compensating external structures.

4.6.2 Local technology networks as trust-compensating and trust-transferring external structures

Similar to publicly coordinated industry-academia R&D programmes, the local professional industry networks examined, namely Technologiekreis Adlershof and OpTecBB at the Adlershof science park, and Círculo de Empresarios de Cartuja at the Cartuja science park, have been detected as important platforms facilitating STP resident firms' interactive relations to academia. This is the case especially for the STP resident businesses categorized as strong knowledge seekers.²³¹ Based on the exclusive focus on the STP scale, the Technologiekreis Adlershof and Círculo de Empresarios de Cartuja primarily promote local interaction, for example, intended and unintended informal exchange of information and knowledge among diverse member organizations, also referred to as local buzz: *"We're member of the Technologiekreis Adlershof just to get a feeling."* (ADL_21).²³²

Firstly, the local technology networks examined focus on specific technology areas or industries. The OpTecBB network, for example, represents companies and scientific institutions focusing on optical technologies in particular. In contrast, the about 90 and 70 members of the Technologiekreis Adlershof and Círculo de Empresarios de Cartuja, respectively, comprise technology-oriented STP resident companies and scientific institutions, which are specialized in technology and research areas that define the two STPs' technology profiles overall (OpTecBB, 2016a; Technologiekreis, 2016a; Círculo de Empresarios de Cartuja, 2016a). Thus, a varying cognitive proximity and knowledge diversity characterize the

²³¹ Almost 62% of the 21 businesses, which are specified as strong knowledge seekers, rated the importance of the local professional networks as settings for industry-academia knowledge relations strongly. In contrast, only ca. 33% and ca. 15% of the firms in the groups of moderate knowledge seekers (n=18) and lame knowledge seekers (n=13), respectively, shared this perception (see Chapter 4.4.1).

²³² In contrast, OpTecBB includes members from the entire Berlin-Brandenburg region (see Chapter 3.1.1).

networks examined and specific internal sub-groups, i.e. communities of practice. This relates to findings of Lazaric et al. (2004) that have pointed to positive effects of the combination of, on the one hand, very specialized professional networks and, on the other hand, more heterogeneous networks combining complementary areas of technology on localized interaction in the Sophia-Antipolis technopolis.

Secondly, the technology networks examined can be primarily characterized as loosely coupled networks with a lack of hierarchy, in which members enjoy a high degree of independence. At the same time, members also take advantage of certain organizational coordination.²³³ For example, the Technologiekreis Adlershof, the OpTecBB network and the Círculo de Empresarios de Cartuja are represented by boards of management, which are elected by the networks' members (OpTecBB, 2016b; Technologiekreis, 2016b; Círculo de Empresarios de Cartuja, 2016b). Following Boschma (2005), networks' non-hierarchical governance, but implicit rules and control mechanisms to penalize and sanction opportunistic behaviour of network members, for example, through exclusion and loss of reputation, refer to a medium-level of organizational proximity.²³⁴ In the examined cases, in particular collective sanctions and reputation mechanisms are found to deter deceptive behaviour.

In addition, multiple interviewees underlined the enhanced probability of finding potential academic cooperation partners with similar expertise and problems to solve in the STP-related technology networks: *"As said earlier, it's easier to find [partners] with similar interests in the Technologiekreis [Adlershof] and OpTecBB."* (ADL_13). Corresponding to findings of Sydow et al. (2011), the rather subtle form of governance and indirect leadership in the local professional networks fosters the development of shared objectives, i.e. institutional proximity, and, in turn, facilitates interaction.

Thirdly, a considerable number of businesses interviewed pointed to the important function of networked reputation among network members for the formation of new relations to associated academic institutions, as the literature has also highlighted for knowledge interaction in general (e.g. Nooteboom, 2000a; Menzel; 2015). One interviewee illustrated the reduction of uncertainty in new knowledge relations within the Technologiekreis Adlershof network based on mediated trust: *"The Technologiekreis Adlershof is a very important or-*

²³³ Industry and technology networks are often led by a hub organization, network orchestrator or a specifically created network administrative organization (Sydow et al., 2011).

²³⁴ Jones et al. (1997) have underlined the concept of network governance in addition to formal rules and authority. It stresses social mechanisms, for example, common norms, collective sanctions and reputation mechanisms, that help to overcome problems of adapting, coordinating and safeguarding interaction and knowledge exchange. In particular reputation mechanisms have been found to be very useful in this respect as actors are very concerned about their own and others' reputation in today's inter-connected economy.

ganization. (...) There're always requests for cooperation. (...) There you can get in touch with the specific persons. (...) This works really well. (...) You can also rely on other network members' opinions and judgements." (ADL_13). An additional firm also emphasized the important role of networked reputation in the OpTecBB network: "The contact was initiated in the OpTecBB network. (...) And there were consultations within the network: We have these problems, which we have to solve. Can you please help us?" (ADL_9).

Moreover, the development of social proximity and trust, but also cognitive proximity is strongly facilitated by repeated personal interaction due to organized geographical co-presence in terms of regular member events, workshops and social activities (see Figure 41). One interviewee underlined the development of personal relationships and also technological reputation in conjunction with intense personal interaction in specialized working groups of the OpTecBB network: "You sit together in the technical committees, and there you get an impression, who has got what kind of capabilities. You also get an impression of scientific institutions once in a while. It's especially about the contacts and about getting known and to develop a technological reputation." (ADL_15).²³⁵ Similarly to the publicly coordinated industry-academia R&D projects, several of the interviewees that are strongly involved in the local technology networks stressed that repeated personal interaction and, if applicable, first shared work experiences within the networks have led to the development of trust-based personal linkages. This interviewee highlighted the importance of personal relationships and trust developed among network member organizations: "Sometimes, it's thru personal contacts in particular, especially within the Technologiekreis Adlershof. (...) There's an openness, which you don't find often." (ADL_19). Again, the positive relation of organizational proximity to social relatedness is demonstrated. Consequently, firms participating in these formal networks take advantage of multiple uncertainty reducing mechanisms in the formation of new knowledge relations to predominantly co-located scientific knowledge sources: firstly, network governance, especially reputation mechanisms, secondly, networked reputation and trustworthiness, as well as thirdly, increased personal trust over time.²³⁶

²³⁵ As already outlined before, also Kujath (2008) has underlined that organizational arrangements enable the reduction of cognitive distance through more frequent intended communication.

²³⁶ Knoben and Oerlemans (2006) have stated that organizational proximity in terms of formal networks is a critical factor for successful knowledge relations over geographical distance as well.

Figure 41: **Members' meeting of *Círculo de Empresarios de Cartuja***



Source: Círculo de Empresarios de Cartuja (2017)

Overall, the strong influence of local formal networks especially observed for the STP resident businesss with strong multi-faceted linkages to co-located academia in the STP (strong knowledge seekers) is related to the organization of multiple fundamental natures of proximity: 1) pooling of related and complementary knowledge organizations, 2) social governance mechanisms in conjunction with a certain institutional relatedness in terms of shared objectives, as well as 3) trust in terms of networked reputation and the development of personal ties. Also, temporary geographical proximity is utilized explicitly to facilitate personal interaction and, in turn, to increase social as well as cognitive proximity between formerly unconnected STP residents from the private sector and academia. In addition, the technology networks also amplify the local buzz in the STP. Similarly to public support schemes of inter-organizational R&D projects, local technology networks are primarily identified as trust-compensating and trust-transferring external settings.

4.6.3 STP-related networking events and conferences as temporary local and trans-local clusters

In the analysis of KNM instruments enabling firms' knowledge relations to academia, local networking events, as well as locally organized industry and scientific conferences have

been identified as important KNM tools overall or to specific knowledge seeking STP resident firms, respectively. While the importance of local networking events for knowledge interaction with academia were emphasized throughout the three different groups of knowledge seekers, only a considerable number of strong knowledge seekers pointed to the significance of locally organized conferences in this respect.²³⁷

Typically, the networking events and conferences associated with the Adlershof and Cartuja science parks focus on specific technology areas or other kinds of specialization, thus, seeking to ensure sufficient similarity of knowledge bases among local and non-local attendants. Furthermore, thematic specialization augments the probability that participating firms and academic entities even are part of the same or related epistemic communities and/or communities of practice. Multiple companies interviewed also underlined the importance of specialized topics of these informal and formal gatherings. To illustrate, one interviewee elaborated on this aspect in regard to STP related networking events: *“(...) it’s more useful to go to events and participate in networks, to which we have intersections as regards to the technology areas.” (ADL_7)*. Thus, cognitive similarity between participants enables the efficient exchange and interpretation of information and knowledge presented, discussed and shared in various ways at the two types of events, as well as sets potential for learning and knowledge creation, as also Henn and Bathelt (2015) have highlighted. In addition to the attendants’ cognitive overlap aspired, Harmaakorpi and Melkas (2005), as well as Bathelt and Zakrzewski (2007) have stressed that the alignment of such industry gatherings by specific themes typically results in a certain institutional proximity as the participating actors usually aim to solve similar problems.

Most importantly, many interviewees underscored that local networking events, such as Academic Lunch at the Adlershof science park and Cartuja 93 Working Breakfast at the STP Cartuja (see Figure 42), primarily help to have initial informal face-to-face contacts with researchers and learn about their expertise, which could meet the firms’ specialized knowledge demands. One company explained this important aspect: *“There’s the Academic Lunch, where one and the other CEO is invited and sits together with university professors at the table. And as soon as three people sit together, they talk ‘what do you do?’ and*

²³⁷ In regard to knowledge interaction with academia, ca. 57% of the businesses categorized as strong knowledge seekers (n=21) evaluated the importance of local networking events strongly. Additionally, approximately 44% and 31% of the firms in two groups moderate knowledge seekers (n=18) and lame knowledge seekers (n=13), respectively, considered them as important.

In regard to industry and scientific conferences organized at the STPs, only ca. 17% and ca. 8% of the firms in these two categories underlined the special significance regarding the facilitation of interactive links to academia. In contrast, ca. 52% of the businesses specified as strong knowledge seekers placed emphasis on such industry gatherings.

'what do you do?' and such things. This is a good setting." (ADL_19).²³⁸ Thus, based on temporary co-presence of similar and complementary actors, the networking events and conferences facilitate personal interaction and may be a starting point for the development of personal relationships. This way, the specialized local networking events complement the general spatial co-location of industry and academia in the two STPs and even reinforce the likelihood of personal interaction of fitting complementary knowledge carriers, that subsequently may result in productive knowledge relations.

²³⁸ A company classified as strong knowledge seeker illustrated the important role of local networking events at the Cartuja science park concerning getting to know suitable scientific knowledge sources in vicinity: *"I have been to the [Cartuja 93] Working Breakfast, which was really interesting, presentations of research groups to businesses. (...) In addition to COPIT and the other networks, this is the best advantage of being in the STP Cartuja."* (CAR_1).

Figure 42: **Cartuja 93 Working Breakfast networking event**



Source: Cartuja 93 (2010b, p. 56)

In addition, locally hosted specialized industry conferences, which often have a regional, national or even international focus, offer enhanced opportunities to develop relations to scientific knowledge sources onsite, but especially also worldwide: *“The contacts are made at conferences, trade shows and presentations. These are good occasions to meet people that work in the same field or something, which may create synergies.”* (CAR_14). Correspondingly, the STP resident firms classified as strong knowledge seekers, characterized by strong local and non-local knowledge linkages to academia, especially use these conferences to absorb new information, as well as to develop and maintain multi-scalar knowledge relations to scientific institutions. In this respect, Bathelt and Schuldt (2008) have referred to global buzz and trans-local pipelines. Consequently, also for these specific cases of STP-related networking events and conferences, the notion of temporary clusters and temporary trans-local knowledge platforms, respectively, as stressed by, for example, Maskell et al. (2004) and Bathelt and Cohendet (2014), is reaffirmed. Overall, it implies that temporary co-presence can enable the access and exchange of non-local knowledge and, thus, also substitute the need for permanent co-location in knowledge relations, as various studies (e.g. Kujath, 2008; Torre, 2008) have highlighted.

In sum, the high overall relevance of networking events and selective importance of industry conferences held at the STPs concerning the facilitation of link creation and knowledge

exchange with academia in the STP and external to the STP is primarily based on the organization of two fundamental dimensions of non-spatial proximity. Thereafter, the thematic specialization of both kinds of events results in the selective attraction of actors with 1) related or complementary knowledge bases, as well as 2) similar objectives and motives. In addition, temporary geographical proximity takes over a crucial function in enabling first personal interaction and, thus, the development of social proximity.

4.6.4 Intermediaries as mediators of cognitive proximity and trust

In the quantitative analysis in Chapter 4.4, a varying boundary-spanning influence on STP resident firms' interactive linkages to academia was identified for the three different types of intermediaries examined: STP management organization, university TTO, as well as regional innovation promoting entities.²³⁹ Among them, a considerable number of firms underlined the relevance to the STP management as well as the regional innovation promoting organizations in particular (39% and 35%, respectively).²⁴⁰ In contrast, only a small fraction of 17% of the 52 businesses assigned importance to the two universities' TTO, which are specialized on the support of university-industry knowledge transfer.

In the interviews, several firms highlighted that the STP management facilitated in the process of the identification of fitting scientific knowledge sources and the formation of linkages. To illustrate, one interviewee highlighted the knowledge brokering function of Cartuja 93: *"They provided the contacts and managed a little bit the project. (...) We were looking for somebody in a certain field, and they provided us with the contacts to the partners. (...) I [also] have a database of specialized research groups, which was forwarded to me by Cartuja 93."* (CAR_16). Similarly, another interviewee from the Cartuja science park explicitly emphasized the crucial boundary-spanning function of the regional innovation entities, for example, CITAndalucía as entry channels to establish links to appropriate research groups on the regional and international scale in particular: *"Maybe, the ones that we have worked with mostly, has been CITAndalucía (...). The truth is that we work with them a lot and we use them as a channel to search for regional partners or outside Spain."*

²³⁹ At the Cartuja science park and in Andalusia in general, a diverse set of regional innovation-related organizations has been identified, e.g. CTA, Agency IDEA, CITAndalucía and FIDETIA. In case of Berlin and the STP Adlershof, Berlin Partner and Technologiestiftung Berlin (TSB) fit into this category (see Chapter 3.1).

²⁴⁰ As outlined in company 4.4, the intermediary role of the STP management was evaluated similarly strongly throughout the three different groups of knowledge seekers (43% | 33% | 39%). In contrast, strong knowledge seekers and moderate knowledge seekers assessed the regional innovation agencies and CIC (43% and 33%, respectively) more strongly than firms identified as lame knowledge seekers (23%). In regard to university TTO, the three groups generally placed similar low emphasis (24% | 17% | 8%).

(...) *They have got a great database and they know what are the research groups in Andalusia and what each research group is doing.*" (CAR_24). The intermediaries' active support in the scanning and identification of suitable knowledge sources by providing knowledge capabilities to client firms has also been stressed in the literature (Howells, 2006; Battistella et al., 2016). In regard to the development of sufficient cognitive proximity between the formerly unconnected actors, Thune (2009) has referred to the role of intermediaries as translators.

Furthermore, several interviewees stressed the intermediaries' assistance in making contacts and in the development of functional relations to new scientific knowledge sources by mediating trustworthiness and reputation: *"Lately, we have received a lot of support by the CTA. (...) So when we need experts, they help us to find the research groups and put us in contact with them."* (CAR_11). This also applies to the development of new relations to academia on the international scale, as this company from the STP Cartuja pointed out: *"The fundamental support of these institutions comes when we, let's say, go to the European level. When we go outside [Spain], these kind of relationships allow us to establish other contacts on the European level."* (CAR_20). Repeated cooperation and the development of personal linkages between the firms and intermediary organizations' management or technical staff further facilitate the transferability of trust to so far unconnected scientific institutions. In addition to the previous statement, the Cartuja-based interviewee placed particular emphasis on the personal relations to intermediaries' technical personnel: *"This is based on personal relationships, too. (...) I also have quite a few years of experience in this field (...) and we know very well to whom we have to go, for example, CTA that is located downstairs. (...) It's always easy to call or meet."* (CAR_20). In this respect, also physical co-location facilitates communication and the development of trust-based linkages between STP resident companies and intermediaries. Especially at the Cartuja science park, a broad range of the relevant regional innovation promoting organizations, for example, CTA, Agency IDEA, CITAndalucía and FIDETIA, maintain offices (see Figure 43). Analogously, the Technologiestiftung Berlin (TSB) maintained an office at the Adlershof science park until 2010 (Expert interview with WISTA-MG, 15 January 2013).

In regard to the mediation of trust and the development of social proximity, respectively, between firms and scientific actors the interviewees also underscored the STP management's role as official organizer of local networking events and conferences, enabling initial personal encounters and informal exchange with potentially suitable knowledge sources, and eventually the formation of new links. One company highlighted the management organization of the Cartuja science park in this regard: *"Fundamentally, it's been through personal contacts, but always under the umbrella of Cartuja 93 (...) with*

distinct activities, events, conferences, talks etc. There, you'll meet research groups and exchange ideas and opinions." (CAR_21). I also discussed the important influence of these two KNM instruments as temporary clusters organized at the two STPs in the previous sub-chapter. Overall, the findings in regard to the reduction of uncertainty and risks of deceptive behaviour in inter-organizational innovation processes relate to an additional important function of intermediaries that has been pointed out in multiple studies (e.g. Nooteboom, 2001; Battistella et al., 2016).²⁴¹

Figure 43: **Agency IDEA at the Cartuja science park**



Source: Author

The low influence of the TTO of the local universities HU-Berlin and University of Seville on STP resident firms' linkages to academia was further validated in the qualitative interviews. Most importantly, many interviewees articulated the TTO's lacking capability to identify knowledge sources that meet a firm's specialized knowledge demands: *"Once, I asked the OTRI [TTO of the University of Seville], if they'd know persons in a certain technology. Two weeks later I got my very own email, if I'd knew somebody. They sent it throughout Spain and were asking, if anybody would know somebody in Seville, and that's why I got it back.*

²⁴¹ Howells (2006) has also underlined the active support of the actual knowledge transfer and processing processes as one of the functions of intermediaries in the innovation process. However, this function was not mentioned in the interviews.

(...) *When you're looking for a person, and this are your experience, you will never try it this way again.*" (CAR_10). Moreover, several firms underlined that the TTO typically focus on their university, thus being constrained to a limited variety of potential scientific knowledge sources. To illustrate, one interviewee remarked: *"Finally, the TTO has got one problem that they are only locally oriented. Thus, they have a problem helping us regarding cooperation with (...) other research centres in other countries."* (CAR_26). Here, the more independent STP management companies and regional innovation promoting entities appear to be better equipped to facilitate the scanning and link creation to a broader range of scientific knowledge sources. In addition, several firms from the Adlershof science park in particular made the low visibility of the university TTO and its services apparent. An interview statement made by an Adlershof resident firm illustrates this problem of the TTO of the HU-Berlin: *"I have the concrete case at the moment that I need a partner that works with radioactive carbon (...). How do I do it? (...) Is there a partner at the HU-Berlin here that I can talk to in order to get an overview? I don't know."* (ADL_21). In this regard, it is important to note that both universities' TTO do not maintain a physical presence in the respective STP. OTRI/STCE of the University of Seville is located in the city centre, while Humboldt-Innovation of the HU-Berlin is only represented through its pre-incubator SPIN-OFF Zone situated in the vicinity to the STP Adlershof (ca. 1 km) since mid 2010 (OTRI Universidad de Sevilla, 2013; HU-Berlin, 2010). Consequently, weak capabilities to find fitting scientific knowledge sources, as well as a lack of visibility in general are as the fundamental obstacles determining the weak intermediary function of the two university TTO overall. These findings also coincide with previous studies (e.g. Siegel et al., 2003c; Fritsch et al., 2007) that have identified lacking capabilities as major causes for university TTO's ineffectiveness.

Overall, intermediaries, especially the two STP management organizations WISTA-MG and Cartuja 93, as well as specific regional innovation promoting entities facilitate the formation of knowledge relations between STP resident firms and academia to a considerable degree. The effectiveness of the intermediaries specified is strongly determined by the ability to 1) find appropriate academic partners and act as translators in order to obtain necessary cognitive proximity, as well as 2) to mediate crucial trust and technological reputation between formerly unconnected firms and local, as well as extral-local scientific institutions.

4.6.5 STP-related knowledge marketing as low-threshold assistance in finding suitable local knowledge sources

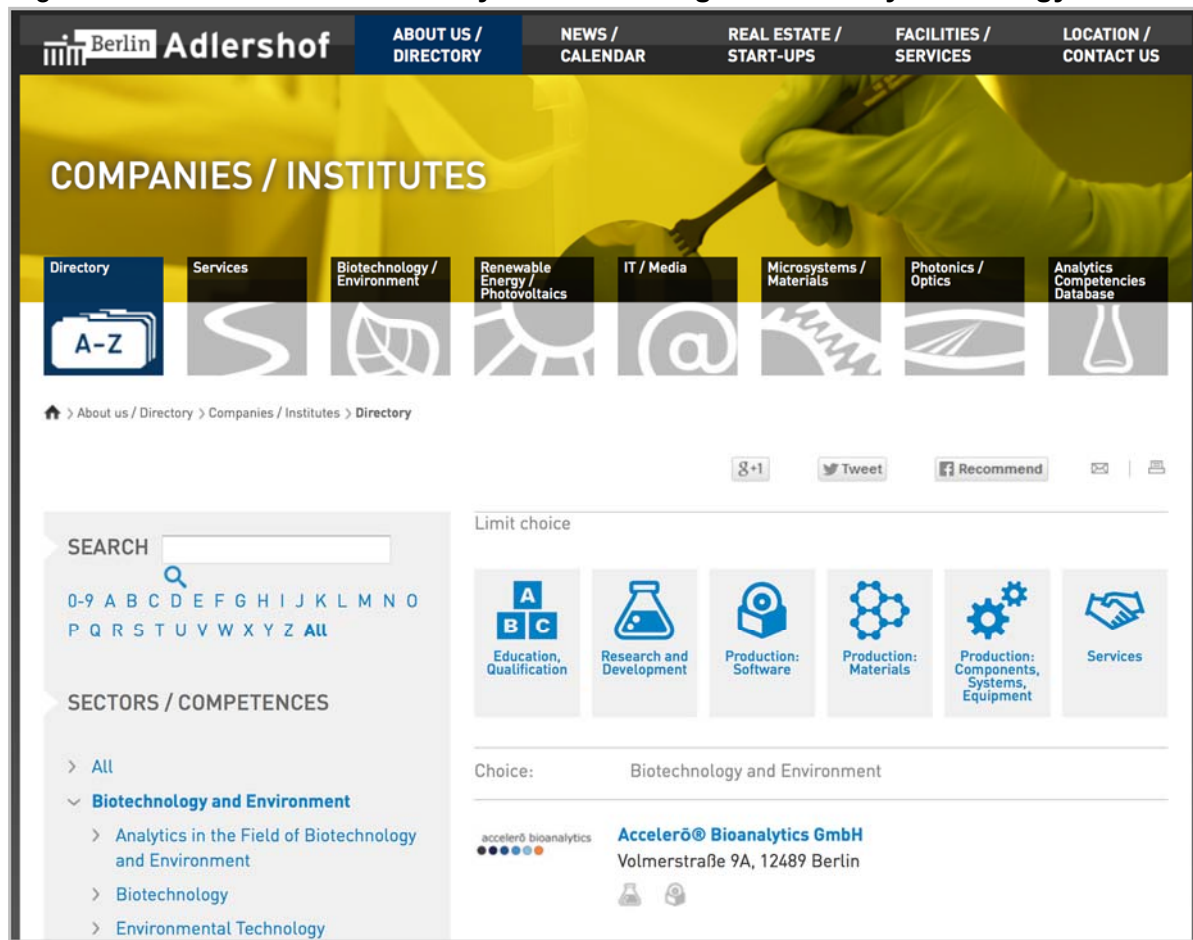
At the Adlershof and Cartuja science parks, only about 19% of the companies placed emphasis on the importance of IT- and print-based knowledge marketing tools (e.g. STP website and related social media channels, databases, newsletters, as well as print magazines) in facilitating knowledge relations to academia (see Figures 44 and 45). Thus, for individual STP resident firms interviewed, this KNM tool still has importance in this respect.²⁴²

In these selected cases, the interviewees underlined the useful character of knowledge marketing linked to the dissemination of information about the STP's diverse resident organizations' competencies, resources and recent activities to enable the identification of suitable scientific knowledge sources and opportunities for cooperation.²⁴³ In other words, knowledge marketing primarily helps to detect cognitively proximate co-located academic institutions. As shown in Chapter 4.4, businesses that are characterized by only marginal interaction to co-located academia due to varying reasons, such as lacking personal contacts and resources, as well as other priorities and interests, disproportionately highlighted this KNM instrument, as one corresponding company stated: *"I especially go through the magazines that come out here every month (...). This way, I get a sense what's happening here."* (ADL_24). Thus, it is assumed that STP resident firms, which are in the initial, preparatory stages of the development of linkages to academia, use the diverse knowledge marketing tools more strongly in order to get a first overview of suitable academic cooperation partners located in vicinity.

²⁴² A small fraction of 19% and ca. 17% of the firms classified as strong knowledge seekers and moderate knowledge seekers, respectively, perceived knowledge marketing as important or very important channel of knowledge relations to academia. In the group of lame knowledge seekers, a slightly larger share of about 23% of the related businesses underlined its relevance.

²⁴³ Lundvall (2006) has stressed that especially explicit knowledge can easily be displayed in databases and IT-based search software tools. Also, IT-based tools have made the display of this kind of knowledge less costly, globally accessible and finding suitable knowledge sources less time-consuming.

Figure 44: **Web-based directory of resident organizations by technology areas**



Source: WISTA-MANAGEMENT (2015) (screenshot by author)

Nonetheless, the low evaluation of the current STP-related knowledge marketing tools in regard to the coordination of knowledge ties to academia is related to several shortcomings. Thereafter, several interviewees demanded more precise information about local scientific institutions' scientific expertise and equipment that could be applicable or available to companies, thus setting potential for interaction. To illustrate, a firm stressed the need for improved information about the supply of academic knowledge at the STP Cartuja: *"For example, we know based on the information by Cartuja 93 that there are about 70 research groups here at the STP Cartuja. But the truth is that, at least from our point of view, we only know of about maybe not more than ten per cent what each of them is doing. What is each research group doing? What are the main fields of activity that are interesting?"* (CAR_21). Furthermore, multiple resident firms requested the more active communication of specific offers and opportunities of mutual R&D activities by the co-located scientific institutions themselves, as one interviewee exemplified: *"The R&D marketing must be extended, especially regarding the publication of research results of the institutes, those that are applicable for a transfer of knowledge to companies, and in which activities the scientific institutions seek partners."* (ADL_2). Consequently, the firms interviewed mainly called for enhanced efforts of STP-related knowledge marketing and information management systems,

respectively, to visualize the specialized knowledge supplied by scientific resident organizations. Also academic actors' specific problems and tasks to solve should be indicated more clearly in order to showcase the institutional proximity among STP resident companies and scientific institutions.

Figure 45: **Regular information magazines issued by WISTA-MG and Cartuja 93**



Source: Author

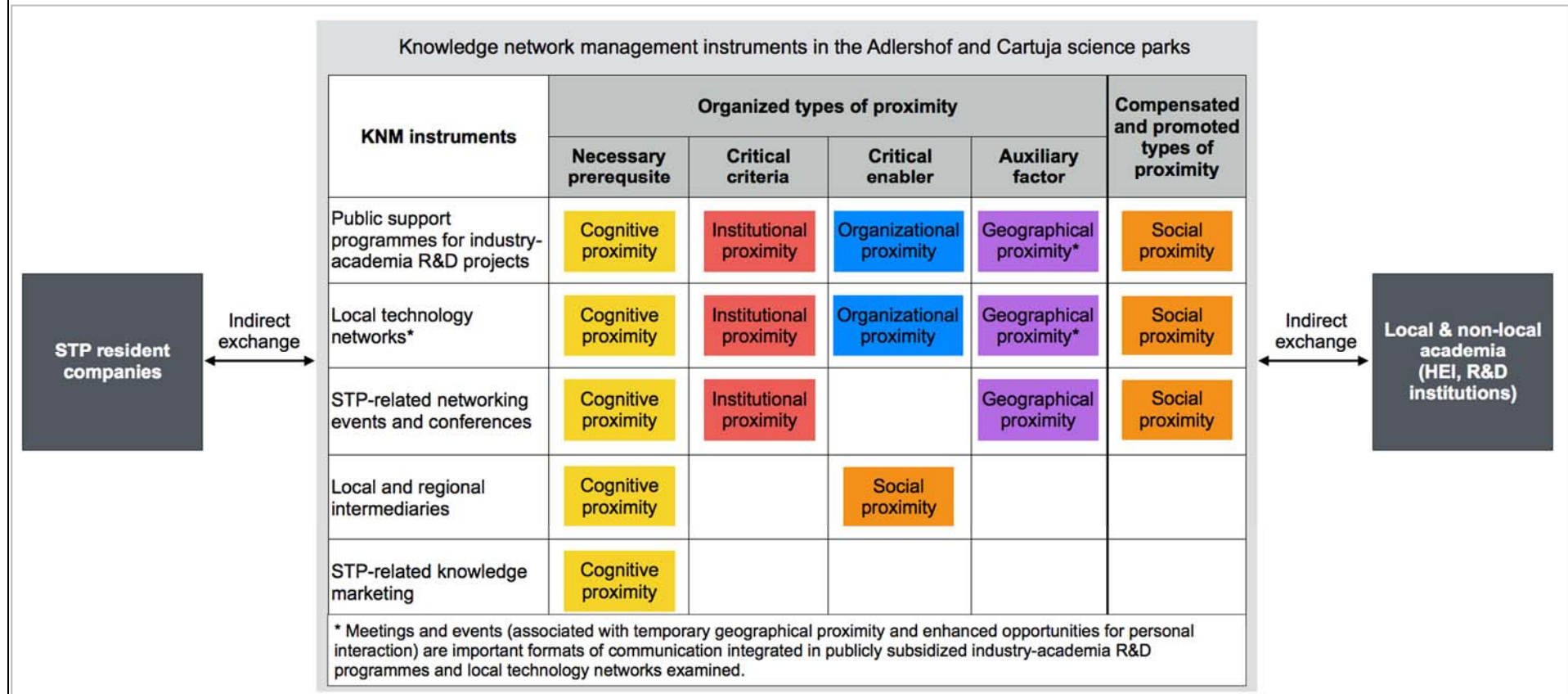
In conclusion, the limited importance of the KNM instrument knowledge marketing on the firms' interaction to academia, in particular concerning scientific institutions co-located in the STP, is based on deficits in helping the firms to find suitable academic partner matches, i.e. cognitively proximate scientific institutions. More importantly however, the knowledge marketing instruments examined at the two STPs are confined to the exclusive function in presenting and finding suitable scientific knowledge sources in the early stages of setting up interactive relations. Thus, they cannot aid in the actual development of functional relations between actors, since they do not organize required critical enabling types of similari-

ty, such as social and organizational proximity. As a result, knowledge marketing is considered as a low-threshold KNM instrument.

Box 12: Preliminary summary of the organization of proximity through knowledge network management

Based on the quantitative analysis in Chapter 4.4, selected KNM instruments, namely public support schemes for industry-academia R&D projects, local technology networks, STP-related networking events and locally organized conferences, as well as selected intermediaries (STP management firms and regional innovation promoting agencies), stand out to be instrumental channels in facilitating local and non-local industry-academia knowledge relationships. At large, in the complementary qualitative analysis in this chapter, I have found that the strong impact of certain KNM tools is based upon the organization of distinct combinations of different proximities. Figure 46 illustrates the specific necessary, critical and auxiliary types of proximity that are organized by the KNM instruments considered to activate, coordinate and harness knowledge relations between STP resident firms and scientific institutions.

Figure 46: **Organization of proximity in indirect knowledge relations between STP resident firms and academia**



Source: Author

Firstly, sufficient cognitive proximity identified as a necessary prerequisite in the STP resident firms' interactive ties to academia also is a fundamental underlying mechanism of effective KNM instruments. This can especially be seen in the strong influence of publicly coordinated R&D projects, formal networks, as well as STP-based conferences and networking events, which are typically specialized on specific themes (i.e. technology areas, research areas and industries), on the cross-institutional knowledge relations examined. Also, for selected intermediaries, who serve as relatively less important entry channels, the supporting function in the process of scanning and identifying suitable knowledge sources was emphasized. However, cognitive proximity as a necessary criterion must be complemented by additional natures of proximity, which actually allow the creation of functional relations to academia. Among others, this is also reflected in the comparatively low relevance assigned to knowledge marketing tools that solely help finding suitable scientific knowledge sources at the STP.

Secondly, the organization of trust-related proximity in terms of either social or organizational proximity, which have been detected as critical enabling factors of the industry-academia knowledge relations considered, is an additional integral component of the most influential KNM instruments. For instance, publicly coordinated industry-academia R&D projects and local formal networks apply certain governance structures associated with formalized or social control mechanisms to compensate for the lack of trust in newly created linkages. In addition, they also promote the development of social proximity and trust by stimulating intense communication and providing opportunities for face-to-face interaction. Furthermore, trusted intermediaries mediate trustworthiness and technological reputation between formerly unconnected actors, while STP-based networking events and conferences promote the development of trust by facilitating personal interaction through temporary geographical proximity. Thus, selected KNM tools capitalize on varying mechanisms to substitute, transfer or promote trust in order to decrease uncertainty and risks of opportunistic behaviour. This also demonstrates that social and organizational proximity can substitute each other due to their similar roles. As a result, sufficiently established trust and certainty, respectively, increases the probability of an open exchange of knowledge in new local or extra-local knowledge relations between STP resident firms and academia.

Thirdly, identified effective KNM instruments also organize shared organizational objectives and work routines despite normally strong institutional discrepancies between the private sector and academia. For example, public support schemes for industry-academia R&D projects and local technology networks exploit either hierarchical coordination structures and financial incentives or more subtle forms of network governance and indirect leader-

ship to harmonize typically diverging organizational objectives and cultures of the two worlds. Also, the thematic alignment of networking events and conferences organized at the STPs is associated with the high likelihood of attending businesses and scientific entities that seeking to solve similar problems.

Ultimately, the most influential KNM tools utilize the indirect and auxiliary function of temporary geographical proximity to increase more critical non-spatial dimensions of proximity, as well as to substitute the need for permanent physical co-location in knowledge relations. In this sense, co-presence is the substantial feature of networking events and conferences to facilitate face-to-face interaction and, consequently, to increase shared cognition and stimulate the development of personal relations. For analogous motives, temporary gatherings also are important elements of the communication regimes of publicly coordinated industry-academia R&D projects and the formal networks in the two STPs.

Overall, by organizing combined proximities, in particular sufficient overlap of knowledge, either trust or organizational closeness, as well as common organizational objectives and work routines, KNM tools such as public support schemes for industry-academia R&D projects, formal technology networks, networking events and conferences, as well as selected intermediaries are found to be effective externally provided channels facilitating successful link creation and knowledge interaction between resident firms in the two STPs and scientific actors both in the vicinity and far away.

In conclusion, in combination with directly established linkages to scientific actors, most of the KNM instruments examined can strongly contribute to a firm's rational and thoroughly planned knowledge interaction and knowledge creation activities with academia. Furthermore, they enable a company to develop a knowledge network to academia, which is characterized by diverse proximity configurations setting the potential for learning and, in turn, innovation: 1) knowledge sources with similar, but also heterogeneous expertise, 2) strongly embedded relationships and newly formed links, 3) local and non-local knowledge relations, as well as 4) loosely coupled networks that combine organizational coordination and flexibility.

5. Overall results, policy recommendations and conclusion

In this chapter, I summarise the key findings of this doctoral thesis. They form the basis for the development of specific policy recommendations. Finally, I offer open questions and needs for further research in the concluding section.

5.1 Overall summary of the results

What defines the innovative approach of this thesis is the applicability of knowledge network management systems in STPs in the organization of distinct types of proximity facilitating the formation and implementation of knowledge relations between STP resident companies and local, but also non-local scientific knowledge sources. For this endeavour, the doctoral thesis has drawn from theoretical concepts from economic geography, as well as knowledge management and organizational learning.

Chapter 2 presented the theoretical framework for the thesis' analysis. Chapter 2.1 outlined the primary statement of problem, which motivated the thesis' analysis throughout. It presented the features of the modern STP, a popular research subject of economic geographers, and the effects concerning its anticipated function as an active knowledge-creating and knowledge-coordinating entity in the globalizing learning economy. However, a relatively moderate level of localized knowledge spillovers and interactive learning between industry and academia has challenged the concept of such designated seedbeds of innovation, which primarily relies on geographical co-location as the fundamental factor for knowledge interaction.

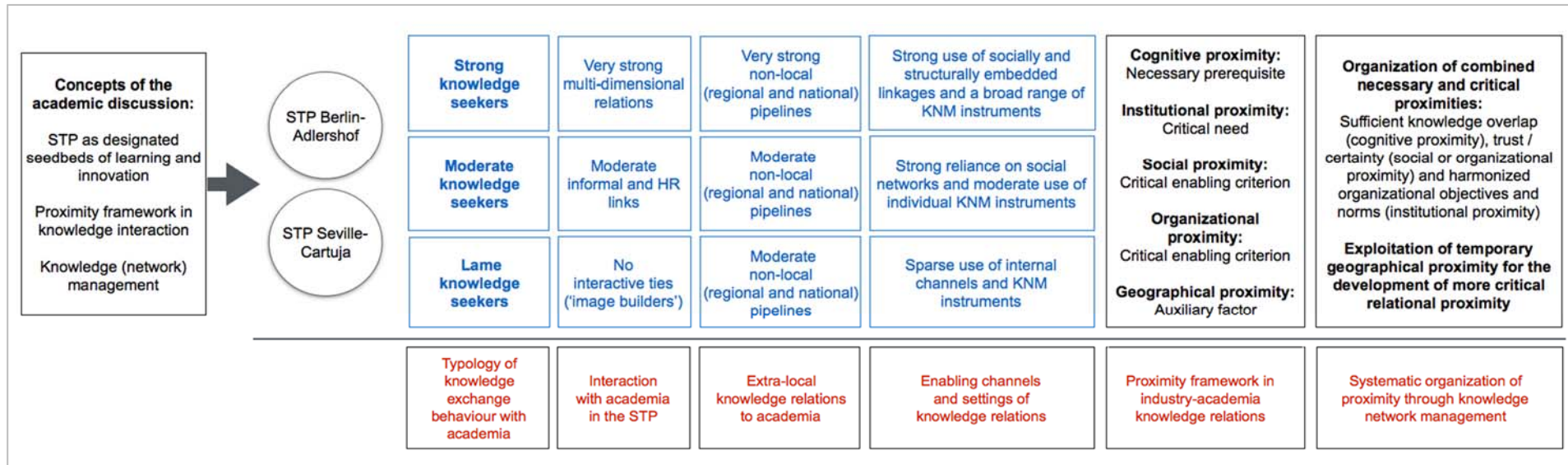
In the theoretical discussion of the proximity framework in Chapter 2.2, the critical function of non-spatial types of proximity, in particular cognitive, social, organizational and institutional proximity, in knowledge relations was underscored. In contrast, spatial co-location is regarded neither as a necessary nor sufficient criterion for successful knowledge interaction, but rather as an auxiliary factor for the development of more fundamental relational natures of proximity on this matter. Drawn from the systematic coordination of organizational learning in firms and inter-organizational alliances, Chapter 2.3 introduced the concept of knowledge management. Furthermore, I showed first examples of local and regional innovation systems, where individual knowledge management instruments or comprehensive systems have been applied to steer and propel cross-institutional knowledge interaction actively.

Drawn from my review of relevant academic literature, I developed five research questions in Chapter 2.4. They aimed to examine the strength, structure and geography of the STP resident companies' egocentric knowledge networks with science. In addition, they sought to identify the enabling channels, as well as to explore the underlying proximity configurations responsible for the formation and implementation of these knowledge relations. In this regard, I aimed to analyse the facilitative role of different knowledge network management instruments and their distinct underlying mechanisms in particular.

Chapter 3.1 presented the structural framework conditions of the Berlin-Adlershof and Seville-Cartuja science parks, where the empirical analysis of resident firms' knowledge networks to academia was realized. In the empirical analysis, I applied a combination of quantitative and qualitative methods, which were described in Chapter 3.2.

Analogue to the sequence of the five research questions, the findings of the empirical analysis, which were illustrated by tables, figures and interviewees' statements, were presented in Chapter 4. The substantial findings of this dissertation thesis are summarized as follows (see Figure 47).

Figure 47: Nexus and summary of the research results



Source: Author

Research question 1 focused on the analysis of the strength, structure and geography of knowledge relations between resident companies in the Adlershof and Cartuja science parks and scientific institutions. Overall, findings presented in Chapter 4.2 stress the importance of multi-faceted (i.e. informal, talent-related and formal) local and non-local knowledge relations to academia for the large share of the 52 examined high-technology firms in the two STPs. This coincides with the increasing empirical evidence for the multiplicity of knowledge relations, i.e. the coexistence of local and extra-local knowledge interaction. In regard to local interaction between resident businesses and co-located scientific institutions the relatively higher relevance of informal and HR linkages compared to formalized cooperation accords with similar empirical studies in STPs in the past. Higher levels of local interaction were generally observed in the Cartuja science park compared to the Adlershof science park. Whereas the University of Seville's School of Engineering was identified as the resident companies' scientific anchor knowledge source in the STP Cartuja, resident firms' knowledge relations in the STP Adlershof comprise a larger variety of co-located scientific institutions. In regard to the firms' strong and versatile non-local knowledge relations to academia, regional and national pipelines to technically oriented universities and applied research oriented R&D institutions are of particular importance. For numerous resident companies examined extra-local knowledge relations to academic institutions are more critical than local interaction with science.

Research question 2 placed emphasis on the identification of specific types of STP resident firms' egocentric knowledge networks to academia. The cluster analysis applied for this purpose resulted in the detection of three groups of STP resident firms characterized by specific knowledge exchange behaviours with academia (see Chapter 4.3). On the one hand, the three different types are primarily distinguished by differing modes and tie strengths of local interaction. On the other hand, the three types of STP resident firms demonstrate the strong relevance of extra-local knowledge sources (global pipelines), although to a varying extent. In more detail, the firms grouped in cluster one feature strong, multi-dimensional relations to scientific institutions located in the STP and also external to the STP and, as a result, were labelled strong knowledge seekers. The companies of cluster two only put an emphasis, though to a relatively smaller degree, on informal and talent-related modes of interaction, and joint R&D projects. Furthermore, these companies also assessed non-local knowledge relations at a comparatively moderate relevance, which resulted in their labelling as moderate knowledge seekers overall. By stark contrast, the third group of so-called unscalable companies does not pursue any interaction with academic entities situated in the STP. This is primarily due to alternative aspirations allocated to the location at a STP such as image advantages, the lack of resources and personal

contacts to academia, or the insufficiently fitting supply of knowledge of local academia. Nevertheless, a majority of them rely on knowledge relations to non-local scientific knowledge sources instead. Due to their marginal interaction with co-located academia, I named the businesses in this group lame knowledge seekers overall.

Research question 3 aimed to identify the channels and settings utilized by STP resident firms to create links and share knowledge with scientific institutions. In this regard, the influence of, on the one hand, specific internal channels and, on the other hand, diverse knowledge network management instruments as transfer channels and platforms was a special focus. As a result of a further quantitative analysis, personal relations and social networks, respectively, were identified as the most important channel of knowledge relations to academia of the 52 STP resident firms overall and throughout the three distinct types of knowledge seekers, indicating the importance of social proximity and socially embedded relations (see Chapter 4.4.1). Furthermore, selected KNM tools, that relate to people management and external structures within the typology of knowledge management instruments, were detected as crucial transfer channels and platforms for the firms' link creation and knowledge interaction with academia: 1) publicly subsidized industry-academia R&D projects, 2) local networking events, 3) local formal networks, as well as 4) the intermediaries STP management organizations and regional innovation promoting entities. Thus, it was shown that in addition to internal channels the KNM instruments highlighted strongly aid STP resident firms in the intended creation and realization of interactive links to scientific institutions located in the STP and external to the STP. In particular the STP resident companies categorized as strong knowledge seekers placed a strong emphasis on internal sources, i.e. personal relationships and inquiries by scientific institutions, and many different KNM tools. Moderate knowledge seekers did so similarly, but a lower degree. In contrast, the businesses specified as lame knowledge seekers primarily rely on their personal relationships and publicly subsidized industry-academia R&D projects only.

Based on the results of the contingency analysis I applied in Chapter 4.4.2, it was concluded that a firm's strong social and structural embeddedness, as well as the active participation in publicly subsidized industry-academia R&D projects on the regional, national and European scale, local technology networks and conferences, often with an international outreach, organized at the STP are important determinants for the development of strong, multi-dimensional local and extra-local knowledge relations to academia.

The processing of the third research question already pointed to certain types of proximity as critical factors in STP resident firms' knowledge relations to academia. A more comprehensive analysis of relevant proximity configurations in this respect was addressed in the research questions 4 and 5.

Research question 4 aimed to explore the specific functions of multi-faceted proximity in a firm's knowledge relations to academia. Based on the qualitative analysis of the role of relational and spatial proximity in the STP resident firms' interactive relations to local and non-local academia in Chapter 4.5, the two tenets identified in the academic discussion of the proximity framework were further substantiated. Subsequently, the outstanding role of sufficient cognitive proximity as necessary prerequisite for knowledge interaction to occur was reaffirmed. In their knowledge relations to scientific actors, whether in the STP or external to the STP, the companies seek similar or diverse, but complementary scientific knowledge that serves to their distinct knowledge demands. Thus, adequate technological closeness is found to be pivotal for the creation and realization of interactive ties with scientific knowledge sources.

Additionally, the qualitative analysis provided evidence that geographical proximity alone is not a necessary or sufficient criterion for knowledge interaction. Instead, it takes over an auxiliary and rather indirect role in the firms' knowledge relations to academia. Yet, geographical proximity is important for the development of local buzz in the STP and also eases other modes of interaction with co-located scientific partner institutions. The primary function of geographical proximity in knowledge relations, however, is to facilitate the development of more critical natures of proximity, in particular cognitive and social proximity, by creating enhanced opportunities for face-to-face interaction. Also, geographical proximity cannot explain the STP resident firms' strong non-local knowledge relations to academia. Here, primarily non-spatial dimensions of proximity are at work.

Furthermore, social and organizational proximity associated with trust and reduced uncertainty are critical enabling factors for link creation and knowledge interaction between STP resident firms and academia, both in the STP and external to the STP. In regard to social proximity, especially shared personal, work, business and study experiences, but also networked reputation strongly determine the likelihood of successful knowledge relations. In contrast, businesses without personal ties to academics generally face high difficulties identifying and accessing fitting scientific knowledge sources. Concerning organizational proximity, in particular formal agreements related to control mechanisms and fixed rules of conduct strongly facilitate cooperation with formerly unconnected scientific knowledge sources, but also already proven academic partners like in the case of academic spin-offs and their scientific parent organizations. In these cases, installed governance structures and control mechanisms reinforce trust previously created in socially embedded relations. Due to their similar roles as enabling factors reducing uncertainty and risks of defective behaviour and, consequently, enabling the open exchange of knowledge, social and organizational proximity can substitute each other.

Ultimately, sufficient institutional proximity in terms of shared organizational objectives and work cultures was identified as a critical issue for the successful initiation and realization of the firms' knowledge relations to academia. Overall, two approaches were identified to cope normally strong institutional dissimilarities between the STP resident companies and science. Thereafter, the companies preferably develop interactive ties to technically-oriented universities and non-university R&D institutions focusing on applied research, which are characterized by less institutional distance. Moreover, personal relationships and organizational arrangements help to identify shared objectives and to harmonize typically differing work cultures.

Finally, research question 5 addressed the need to determine to which extent the specific KNM instruments organize proximity to facilitate industry-academia knowledge relations. Corresponding to the previously identified relevant proximity framework in industry-academia knowledge relations, the qualitative analysis laid out in Chapter 4.6 found that the organization of sufficiently overlapping knowledge bases and, thus, the enhanced likelihood to engage in meaningful interaction is key to the effectiveness of KNM. In addition, the distinct KNM tools explicitly organize additional, especially non-spatial types of proximity, which were identified as critical criteria for the formation and realization of knowledge relations between the STP resident firms and academia.

In this regard, the qualitative analysis provided proof that the most instrumental KNM instruments capitalize on varying mechanisms to substitute, transfer or promote trust and, in turn, to decrease uncertainty and risks of opportunistic behaviour. This is essential to enable the open sharing of knowledge in local or non-local knowledge relations between STP resident firms and academia. Showcasing that social proximity can be substituted by organizational proximity, coordinated industry-academia R&D projects and local technology networks apply either formal governance and control mechanisms or reputation mechanisms to compensate for the lack of social proximity and trust in newly established linkages. Furthermore, they also foster the development of social proximity and trust by stimulating intense communication and providing opportunities for face-to-face interaction over time. Trusted intermediaries such as the STP management firms and regional innovation promoting agencies transfer trustworthiness and reputation between formerly unrelated actors, referring to the importance of networked reputation. STP-based networking events and conferences facilitate face-to-face interaction through temporary co-presence, thus promoting the development of personal ties this way.

Moreover, the effective KNM instruments examined also steer the identification of shared organizational objectives and work cultures despite normally strong institutional dissimilarities between companies and scientific institutions. The public support programmes for in-

industry-academia R&D projects utilize hierarchical coordination structures and financial incentives to stimulate the identification of shared objectives. The local technology networks do so by exploiting more subtle forms of social governance and indirect leadership. Also, the specified thematic focus of the STP-related networking events and conferences examined increases the likelihood that participating companies and scientific actors share similar motivations and need to solve related problems.

Finally, the most effective KNM tools utilize the indirect and auxiliary function of temporary geographical proximity to create more critical non-spatial dimensions of proximity, as well as to substitute the need for permanent co-location in knowledge relations. Accordingly, temporary geographical proximity is an integral element of the locally organized networking events and conferences to facilitate personal interaction and, in turn, to augment social and cognitive proximity. For analogous motives, the publicly coordinated industry-academia R&D projects on the regional, national and international scale, as well as the local technology networks in the two STPs organize regular meetings and events as part of their communication formats. On the whole, the organization of temporary geographical proximity through KNM is an important factor in facilitating the local, but in particular the non-local knowledge relations of the resident companies to scientific actors.

In sum, through the systematic organization of multi-faceted proximity, in particular in regard to the sufficient congruence of knowledge bases, reduced uncertainty based on personal trust or organizational governance, as well as shared objectives and work routines, the KNM instruments underlined strongly assist in a firm's intended knowledge interaction and knowledge creation activities with both local and extra-local academia. Furthermore, KNM can contribute to knowledge interaction with variously proximate and distant scientific knowledge sources at the same time creating enhanced potential for learning and innovation: 1) similar and rather heterogeneous expertise, 2) socially embedded and newly formed relations, 3) local and extra-local linkages, as well as 4) ties combining organizational coordination and flexibility.

5.2 Policy recommendations

The central findings presented in Chapter 5.1 lend themselves to the development of specific hands-on policy recommendations, which aim to enhance the STPs' role towards active knowledge-creating and coordinating institutions in the knowledge-based economy. Consequently, the policy implications are primarily addressed to managers of modern STPs, but also to other stakeholders and industry-academia interfaces in regional innova-

tion systems more generally. Overall, the objective of the policy recommendations generated by this research project is to foster versatile and multi-scalar, i.e. local and extra-local, knowledge relations of STP resident firms to academia:

1. Ensuring a related variety of knowledge organizations in the STP:

- Already in the early stages of planning and developing a STP, the stringent definition of the tenant composition based on similar or complementary knowledge bases and compatible organizational cultures, as well as its continuous application are crucial prerequisites for local interaction and interactive learning to take place. Although the planning and development process of science and technology parks is often strongly influenced by political decisions, as shown in the examples of the STPs Berlin-Adlershof and Seville-Cartuja, yet a comprehensive analysis showing that potential resident businesses and scientific institutions can indeed contribute to the desired creation of synergies to business, technology and innovation is mandatory. The planning process of the Cartuja science park, within which, for example, the University of Seville's faculties of humanities were excluded from the university's relocation plans to the STP due to a confined potential concerning localized learning, illustrates the important necessity of related variety by design in STP planning and the day-to-day management at a later point.

2. Installation and orchestration of a comprehensive knowledge network management system that organizes necessary and critical types of proximity:

The development and application of a multi-faceted KNM system in STP is key to facilitate multi-faceted, local and non-local knowledge relations of resident firms to academia. A KNM system adds steering and governance mechanisms to strengthen proximities, which should be already inherent to STP by concept, and, thus, can significantly enhance its knowledge-creating and coordinating function in RIS and in the learning economy more generally. In this regard, individual KNM tools to be implemented should address actors in distinct and complementary technology areas, implicate trust-compensating, trust-mediating or trust-promoting mechanisms, as well as ensure shared motivations at the same time. Suggestions are primarily drawn from selected KNM instruments examined, of which a strong influence on the creation and realization of knowledge relations I showed empirical proof for in Chapters 4.4 to 4.6. Additional input is gained from policy evaluations and international examples of good practice.

- As it is unlikely that a STP possess the financial resources to subsidize industry-academia R&D projects on its own, the STP management should facilitate the access of resident firms to available private or public support programmes for industry-academia R&D projects and other kinds of cooperation (e.g. talent mobility). Conse-

quently, the STP management should monitor and provide easy-to-access and comprehensible information about related framework conditions, eligibility criteria and responsible coordinating entities of present and projected support schemes on the different geographical scales.

- The STP management should assist in the development and the activities of local technology networks. Formal networks should include resident organizations in specialized technology areas, but also facilitate the access to heterogeneous, complementary knowledge sources. The orchestration of interrelated, but distinct technology networks for each of the two purposes at the Sophia-Antipolis technopole provides a good example, which has already shown positive effects (Lazaric et al., 2004). Furthermore, the STP management should support the networks building relations to corresponding non-local communities of practice, technology networks, cluster organizations and so on.
- The STP management should organize or support the organization of temporary clusters in terms of networking events and conferences that focus on specific industries, technologies and other kinds of specialization. For the former, local networking and matchmaking events should also be designed to meet the distinct needs and demands of the specific target groups in business and science in terms of appropriate format, time, duration, interval and size of event. They should also be communicated effectively inside and outside the STP. For conferences in particular, a STP should attract or organize industry gatherings with a national or international outreach in order to enable on-park firms to develop knowledge ties to fitting non-local sources of scientific knowledge, as well.²⁴⁴
- A capable, reputable and service-oriented intermediary organization, which assists resident companies in gaining access to a broad range of local and non-local scientific knowledge sources, should be installed on-site. For the effective support in the development of industry-academia collaborations in the field of technological development and innovation, the knowledge broker should map the expertise and resources of local scientific organizations and determine to which extent they are available to external actors (supply analysis). Furthermore, the specific and most appropriate competencies and resources required to support resident businesses' technological development and innovation needs have to be identified (demand analysis). To illustrate, the AREA science park in Trieste (Italy) has implemented such compre-

²⁴⁴ As additional informal settings of local networking, STP-based demo shows, as well as site visits at resident firms and scientific institutions organized for specific technology areas may provide enhanced opportunities to get to know about co-located actors' products, work processes, research activities and the relevant persons behind them more profoundly.

hensive, duplex analysis as integral methodological element to optimize the match-making capability of its innovation management system (UNIDO, 2014). In general, policy reports evaluating the effects of public knowledge transfer agencies have underlined that multiple, small-scale knowledge brokers that operate in parallel in the same region should be avoided. Instead it is argued that well-resourced key intermediaries with staff experienced in business and science ensure a higher visibility, capability and effectiveness in assisting in industry-academia knowledge sharing processes (MR et al., 2012). For the effective support in the development of extra-local knowledge relations to academia, the knowledge broker should develop stable partnerships to specific academic institutions and equivalent intermediary organizations in other regional, national and international knowledge hubs.²⁴⁵

- In its knowledge marketing activities, the STP management should continuously provide up-to-date and meaningful information about the distinct knowledge supply of on-park organizations and potential opportunities for interaction using various channels of communication. Furthermore, as shown by Lazaric et al. (2004, 2008) for a similar project at the Sophia-Antipolis science park, particularly the active integration of tenant organizations in the process of mapping local knowledge and expertise can be a starting point for first interaction and, subsequently, the formation of knowledge relations.
- In addition to social meeting places such as cafés and restaurants as part of a STP's urban infrastructure and atmosphere, the STP management should create or encourage the development of theme-based collaborative and interactive spaces to provide enhanced opportunities for shared work experiences (co-working, collaboration and even co-teaching)²⁴⁶, as well as for intended and unintended personal encounters. As Schmidt et al. (2014) and Ibert et al. (2015) have stressed, the variety of such collaborative and interactive spaces with a certain specialization may comprise (permanent or temporary event-like) cross-institutional creative and innovation labs, open or member-based high-tech workshops, such as Maker Spaces and hacker spaces, as well as co-working spaces.²⁴⁷

²⁴⁵ For the STP management company, corresponding formal networks are, for example, the International Association of Science Parks and Areas of Innovation (IASP) and national equivalents. Furthermore, the Enterprise Europe Network set up by the European Commission can be named.

²⁴⁶ For example, at the Center for MIT Entrepreneurship, entrepreneurs and academic staff jointly teach most of the courses (Lüthje & Franke, 2002).

²⁴⁷ In this regard, the effects of, for example, the Adlershof-based open innovation platform Innovation Network Advanced Materials (INAM), which has been established in 2016 and comprises a large variety of the local and regional triple helix as well as partners external to the region, will be interesting to assess. INAM includes the accelerator programme Advanced Materials Competition (AdMACom) and specific shared innovation infrastructure (Neumann & Brinkhoff, 2016).

3. Design of special KNM instruments that empower STP resident firms with a lack of own entry channels and resources:

In addition to low internal capabilities and resources hindering first interactive or collaborative activities with academia, these firms, primarily categorized as lame knowledge seekers, often have not taken advantage of any relevant assistance in this respect. Instead, they often consider available support instruments ineffective and too time-consuming. Consequently, specific low-threshold assistance linked to low search and transaction costs should be provided for this special target group.

- Intermediaries should take over a more proactive and complex function order to reduce the obstacle of high search and transaction costs (in German: Kümmerer). As Howells (2006) has underlined, they should actively increase a company's internal capability regarding the scanning, identification and validation of suitable external knowledge and related knowledge sources, assist in the development of functional relations by mediating trust, as well as sometimes even control the actual knowledge transfer process.
- So-called innovation vouchers have been evaluated as effective, low-threshold financial support schemes to stimulate the development of first interactive relationships between SMEs and scientific institutions (KTI, 2011).²⁴⁸ Typically, streamlined application processes and the support of small-scale joint R&D and innovation projects characterized these financial support programmes, which have been increasingly installed in regions and on the national scale in Europe (Prognos AG, 2011). Consequently, the risk of high sunk investments in case of inefficacy of first cooperation is reduced.
- The STP management company in cooperation with resident businesses and scientific institutions should facilitate informal and talent-related interaction in terms of, for example, student placements, talent exchange and the use of specific scientific equipment. Initial informal and HR links can serve as a starting point for formal and more long-term interaction. For instance, externally supported placements of researchers in resident firms have shown positive effects on localized knowledge interaction in Japanese STPs (Fukugawa, 2010).²⁴⁹

²⁴⁸ In case of the Cleantech Innovation Voucher provided by the Commission for Technology and Innovation (KTI) in Switzerland, ca. 40% of the participating companies in 2010 cooperated with scientific institutions for the first time. Also, a share of about 85% participated in a public support scheme for industry-academia cooperation for the first time (KTI, 2011).

²⁴⁹ Public support programmes of talent mobility from universities to technology firms have not been subject of analysis in this dissertation thesis. However, programmes like Innovationsassistent in Berlin aim to combine two advantages. On the one hand, they facilitate SMEs to access up-to-date scientific knowledge. On the

Altogether, the regular evaluation of the installed KNM system regarding the generated effects in relation to the expected impact is essential in allocating limited resources efficiently. Furthermore, it allows continuous adjustments and improvements in order to respond to new demands of diverse STP resident knowledge organizations and the learning economy.

5.3 Conclusion

This dissertation has focused on the analysis of the proximity framework in industry-academia knowledge relations and the applicability of the concept of knowledge management to the scale of local innovation systems such as science parks to steer knowledge interaction externally. Based on the empirical analysis of egocentric knowledge networks to academia of STP resident firms of the Adlershof and Cartuja science parks, significant results have been obtained concerning the strength, structure and geography of such interactive ties, the proximity configurations responsible for successful link creation and knowledge interaction, as well as the influence and underlying mechanisms of specific knowledge network management instruments. Throughout this thesis, I gave an overview of the specific findings in preliminary summaries. For a final overview, I present the value of the results to the existing academic literature and to the development of hands-on policy recommendations for the innovation management in STPs.

New results for existing academic knowledge

- The dissertation found evidence that KNM, which organizes combinations of essential, critical and auxiliary types of proximity, can systematically promote effective knowledge relations between formerly unrelated resident firms and academia in specific localities of learning such as STPs and on other geographical scales. The underlying mechanisms of effective KNM instruments illustrate the importance of multi-faceted proximity in knowledge relations. In this regard, KNM also exploits trade-offs and compensatory functions between specific types of proximity.
- KNM instruments can contribute to a firm's knowledge network to academia, which is characterized by optimal levels of proximity setting the potential for learning and inno-

other hand, they allow SMEs to leverage usually high labour costs (for a defined period of time) and, as a result, help companies with limited financial resources to attract highly qualified scientific talent (Investitionsbank Berlin, 2017).

vative performance: 1) interactive ties to scientific knowledge sources with similar, but also heterogeneous expertise, 2) strongly embedded relationships and newly formed links, 3) mix of local and non-local knowledge relations, and 4) loosely coupled systems that combine organizational coordination and flexibility.

- The importance of multi-faceted proximity was reaffirmed for knowledge relations between technology-oriented businesses and scientific institutions. The outstanding position of cognitive proximity as a necessary prerequisite for successful knowledge interaction to take place was validated. Permanent or temporary geographical proximity primarily takes over a critical function for the development of more crucial non-spatial natures of proximity. Non-spatial natures of proximity can work independently from geographical proximity, in particular in extra-local knowledge relations.
- Social networks were identified as crucial entry channels for the formation of industry-academia knowledge relations. In general, social and organizational proximity were detected as major enabling factors, which can substitute each other. In addition, they also may compensate for normally too large institutional dissimilarities between the private sector and academia.
- The analysis of the geography of STP resident companies' knowledge relations to academia provides additional input to the debate on the multi-scalar process of knowledge sourcing, knowledge interaction and learning, also reflected in specific terms widely used in the literature such as local, global and virtual buzz, or trans-local pipelines.
- The distinct types of knowledge seekers and related patterns of knowledge interaction with co-located academia in the STP extend the empirical state of knowledge on the varying motive forces of STP resident firms and perceived advantages of their location at a STP.

Taking this dissertation's main results into account, I articulated several policy recommendations for the effective orchestration of KNM systems in STP in specifically and RIS in general in Chapter 5.2. A brief summary is presented below.

Application of the main results to the management of STP and RIS

The results of this dissertation thesis provide important conclusions for innovation management in STPs, as well as other local and regional innovation systems. The explicit organization of proximity through knowledge network management allows the systematic support of multi-scalar knowledge relations of companies to academia.

- The steering of the STP tenant composition based on the definition and application of stringent admission criteria already starting from the planning and development stage of a STP is important to ensure sufficiently related knowledge bases, as well as common organizational objectives and cultures among resident knowledge organizations. A related variety by design in a STP sets the basis for localized knowledge interaction and learning, in particular between technology-oriented businesses and scientific institutions.
- STP should install a KNM system that provides versatile assistance to resident firms in the development of linkages to scientific knowledge sources in the STP and external to the STP. Parallel and competing offers should be avoided, also in order to allocate often times scarce public resources efficiently and, likewise, to reduce search and transaction costs for businesses. Thus, I argue that a KNM system should be orchestrated by a central entity or based on a consensual process among relevant stakeholders in the STP.
- The KNM system should include trust-compensating, trust-mediating and trust-promoting KNM tools, which implicate a specialization in specific areas of knowledge and technology. Accordingly, in particular theme-aligned formal networks, networking events and international industry gatherings (e.g. conferences), public support schemes for industry-academia cooperation, as well as well-connected and trusted intermediary organizations strongly contribute to knowledge interaction with local and non-local scientific institutions.
- Specifically designed low-threshold KNM instruments, for example, innovation vouchers and comprehensive knowledge brokering services, can aid STP resident companies with very limited resources and affiliations to scientific entities to realize first interaction with academia.

Research needs

The findings presented in this doctoral thesis show that further research should to be undertaken in the following avenues of research:

- Further empirical analysis is required to examine the dynamic evolution of multifaceted proximity in knowledge relations over time, especially when interactive links stagnate (lock-in) or before they are dissolved. Among others, Balland (2012) as well as Ibert and Müller (2015) have conducted initial studies.
- In order to generate additional empirical findings, similar studies could analyse the effects of proximity-organizing KNM systems on local and non-local knowledge interac-

tion in case of specific localities of learning such as STPs located in other territorial innovation systems, for example, in North America, South America, Asia and Africa.

- The proximity dynamics and applicability of knowledge network management in innovation networks and systems, which also engage citizens and end-users (quadruple helix), and additional actors and subsystems (N-tuple of helices) in technological development and innovation processes, could also be an important subject for future research.

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Appendix A

Table A1: List of interviewed companies at the Adlershof and Cartuja science parks

Interview code	Science park	Position of interviewee
ADL_1	Adlershof	Managing Director
ADL_2	Adlershof	Managing Director
ADL_3	Adlershof	Managing Partner
ADL_4	Adlershof	Managing Director
ADL_5	Adlershof	Managing Director
ADL_6	Adlershof	Managing Director
ADL_7	Adlershof	Managing Director
ADL_8	Adlershof	Managing Director
ADL_9	Adlershof	Managing Directors
ADL_10	Adlershof	Managing Director
ADL_11	Adlershof	Managing Director
ADL_12	Adlershof	R&D department
ADL_13	Adlershof	Managing Director
ADL_14	Adlershof	General Manager Sales und Business Development CSS
ADL_15	Adlershof	Managing Director
ADL_16	Adlershof	Managing Director
ADL_17	Adlershof	CTO
ADL_18	Adlershof	Managing Directors
ADL_19	Adlershof	Managing Director
ADL_20	Adlershof	Managing Director
ADL_21	Adlershof	Managing Director
ADL_22	Adlershof	Managing Director
ADL_23	Adlershof	Managing Director
ADL_24	Adlershof	Managing Director
ADL_25	Adlershof	Software development
ADL_26	Adlershof	Managing Director
CAR_1	Cartuja	Project Manager
CAR_2	Cartuja	General Manager
CAR_3	Cartuja	General Manager
CAR_4	Cartuja	General Manager
CAR_5	Cartuja	General Manager
CAR_6	Cartuja	President
CAR_7	Cartuja	Innovation Manager
CAR_8	Cartuja	Executive Manager
CAR_9	Cartuja	Managing Partner
CAR_10	Cartuja	CEO
CAR_11	Cartuja	Investments and Subsidies
CAR_12	Cartuja	CEO
CAR_13	Cartuja	Managing Director
CAR_14	Cartuja	Innovation Department
CAR_15	Cartuja	Financial Controlling

Interview code	Science park	Position of interviewee
CAR_16	Cartuja	Director of the Engineering department
CAR_17	Cartuja	Director of Finances and Administration; Regional Manager
CAR_18	Cartuja	Managing Partners
CAR_19	Cartuja	General Manager
CAR_20	Cartuja	Director for cooperation services; R&D Coordinator
CAR_21	Cartuja	CEO
CAR_22	Cartuja	CEO
CAR_23	Cartuja	President
CAR_24	Cartuja	Regional Manager
CAR_25	Cartuja	CEO
CAR_26	Cartuja	Innovation Director

Table A2: **Expert interviews**

Name (position and organization)	Date
Charo Romero García (Technical Department, Cartuja 93, S.A.)	23 November 2010
José Antonio Pascual Sánchez (Director of Innovation, Programmes and Advanced Services, Agency IDEA)	25 March 2011
Eva Martin Ruiz (Department of Innovation, Cartuja 93, S.A.)	4 April 2011, 24 September 2012
Luis Pérez Díaz (Department of Innovation, Cartuja 93, S.A.)	4 April 2011
Yvonne Plaschnick (Department of Business Development, WISTA-MG)	30 September 2011
Dr. Helge Neumann (Department of Business Development, WISTA-MG)	15 January 2013, 10 July 2015
Björn Jäger (Engagement-Verantwortlicher, Investitionsbank Berlin)	18 February 2013
Prof. (em.) Dr. Josef Nipper (Department of Geography, University of Cologne)	7 July 2016, 6 September 2016
Prof. Dr. Oliver Ibert (Leibniz Institute for Research on Society and Space, Erkner)	16 February 2017

Figure A1: Cover letter, questionnaire, interview topic guide for interviews at Adlershof science park (Know-Man project)

Berlin, 22. Oktober 2010



Herr/Frau ...
...
...

Betreff: Interview zur Vernetzung zwischen Unternehmen und Forschungseinrichtungen

Sehr geehrte(r) Herr/Frau,

das Projekt Knowledge Network Management in Technology Parks (Know-Man) zielt darauf, Innovationen voranzutreiben. Die Vernetzung von Unternehmen mit Universitäts- und Forschungseinrichtungen soll dabei optimiert werden. Insbesondere Existenzgründer sowie kleine und mittelständische Unternehmen im Wissenschafts- und Technologiepark Adlershof können von den verbesserten Leistungen profitieren.

Die Unternehmensbefragung in Berlin Adlershof dient dazu, den Bedarf der Unternehmen nach Instrumenten des Wissensmanagements zu erheben. Die Ergebnisse werden in eine Vergleichsanalyse aller im Projekt beteiligten Regionen einfließen. Die abgeleiteten Handlungsempfehlungen werden praktisch umgesetzt und tragen maßgeblich zur Entwicklung einer verbesserten Angebotspalette für Unternehmen im Wissenschafts- und Technologiepark Adlershof bei.

Zur Bewertung der derzeitigen Situation und insbesondere zur zukünftigen Gestaltung des Wissensmanagements für innovative Unternehmen am Standort möchten wir Ihr Unternehmen gerne einbeziehen. Ich freue mich sehr, wenn Sie zu einem persönlichen Gespräch zur Verfügung stehen können.

Alle im Rahmen der Befragung gesammelten Daten und Informationen werden höchst vertraulich und anonym behandelt. Für Rückfragen zu Know-Man oder der Befragung stehe ich Ihnen gerne zur Verfügung!

Vielen herzlichen Dank für Ihre Zusammenarbeit bereits im Voraus!

Mit freundlichen Grüßen,
Sascha Brinkhoff

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1 FRAGEBOGEN (STAND. INTERVIEW)

Datum, Ort:
Name des Unternehmens:
Gesprächspartner (Funktion im Unternehmen):

A. Fragen zum Unternehmen	
1	Wann und wo wurde das Unternehmen gegründet? Zeitpunkt (MM/JJJJ): _____ Ort: _____ <small>(wenn außerhalb vom Wissenschafts- und Technologiepark Adlershof bitte weiter mit Frage 1a)</small>
1a	Seit wann sind Sie mit Ihrem Unternehmen im Wissenschafts- und Technologiepark Adlershof? <small>(bitte jeweils den Monat und das Jahr (MM/JJJJ) angeben)</small>
2	Wie viele Beschäftigte sind insgesamt aktuell in Ihrem Unternehmen tätig? darunter: Vollzeitbeschäftigte _____ FuE-Personal _____
3	Wie hoch war Ihr Umsatz im letzten Jahr? <div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> bis 2 Mio. € <input type="checkbox"/> mehr als 10 Mio. € bis 50 Mio. € <input type="checkbox"/> keine Angaben </div> <div> <input type="checkbox"/> mehr als 2 Mio. € bis 10 Mio. € <input type="checkbox"/> mehr als 50 Mio. € <input type="checkbox"/> keine Angaben </div> </div>
4	Wie hoch war der Anteil der Ausgaben für Forschung und Entwicklung (FuE) am Umsatz (geschätzter Anteil in % am Umsatz in 2009)? <div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> keine FuE <input type="checkbox"/> 1 - 2 % <input type="checkbox"/> 3,5 - 8,5 % <input type="checkbox"/> keine Angaben </div> <div> <input type="checkbox"/> bis 1 % <input type="checkbox"/> 2 - 3,5 % <input type="checkbox"/> mehr als 8,5 % </div> </div>
5	Welches sind die Tätigkeitsschwerpunkte Ihres Unternehmens? <small>(Mehrfachnennungen möglich.)</small> <div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> Produktion / Herstellung <input type="checkbox"/> Forschung und Entwicklung </div> <div> <input type="checkbox"/> Aus- und Weiterbildung <input type="checkbox"/> Handel / Vertrieb </div> </div>



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	<input type="checkbox"/> Beratung / wirtschaftsnahe Dienstleistungen	<input type="checkbox"/> Sonstiges (bitte nennen) _____
6	Unter welche der vorgegebenen Branchen fällt ihr Unternehmen? (Mehrfachnennungen möglich.)	
	<input type="checkbox"/> Biotechnologie	<input type="checkbox"/> Umwelttechnologie
	<input type="checkbox"/> IT	<input type="checkbox"/> Medien
	<input type="checkbox"/> Optik / Photonik	<input type="checkbox"/> Mikrosysteme
	<input type="checkbox"/> Materialtechnologie	<input type="checkbox"/> Photovoltaik
	<input type="checkbox"/> Sonstiges (bitte nennen) _____	
7	Wie definieren Sie Ihr Unternehmen?	
	<input type="checkbox"/> Ausgründung aus einer Hochschule (bitte spezifizieren Sie welche Hochschule) _____	
	<input type="checkbox"/> Ausgründung aus einer außeruniversitären FuE-Einrichtung (bitte spezifizieren Sie welche FuE-Einrichtung) _____	
	<input type="checkbox"/> Ausgründung aus einem Unternehmen (bitte spezifizieren Sie welches Unternehmen) _____	
	<input type="checkbox"/> Unabhängig von anderen Einrichtungen/Firmen gegründetes Unternehmen	
	<input type="checkbox"/> Tochterunternehmen / Unternehmensniederlassung (Vertrieb o.ä.)	

B. Zusammenarbeit mit wissenschaftlichen Einrichtungen

1. Wie schätzen Sie die Intensität der Zusammenarbeit Ihres Unternehmens mit wissenschaftlichen Einrichtungen allgemein in den letzten drei Jahren ein? (Bitte bewerten Sie auf einer Skala von 0 – 5; wobei 1 = einmalige Kooperation und 5 = intensive regelmäßige, vielfältige Zusammenarbeit)
keine Zusammenarbeit <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>

2. Formen und Bewertung der Zusammenarbeit mit wissenschaftlichen Einrichtungen insgesamt und der Humboldt-Universität (HUB) im Speziellen im Wissenschafts- und Technologiepark Adlershof . (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)		
	Nicht wichtig ----- Sehr wichtig	Nicht zu-
	1 2 3 4 5	treffend
Persönliche Kontakte (z.B. Professoren, wissenschaftliche Mitarbeiter)	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>



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2. Formen und Bewertung der Zusammenarbeit mit wissenschaftlichen Einrichtungen insgesamt und der Humboldt-Universität (HUB) im Speziellen im Wissenschafts- und Technologiepark Adlershof . (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)		
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Nutzung der Infrastruktur, z.B. Ausrüstung (z.B. Labor-/ Testeinrichtungen) und Fachliteratur (Bibliothek, Forschungsberichte)	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Besuch von Veranstaltungen (z.B. Seminare, Vorlesungen, Workshops)	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Beteiligung von Studenten / wissenschaftlichen Mitarbeitern an Projekten und Anwerbung von Personal (z.B. Praktika, stud. Hilfskräfte, Abschlussarbeiten, Dissertationen)	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Austausch von Wissenschaftlern / FuE-Personal	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Training / Weiterbildung für Beschäftigte	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Nutzung von Beratungsleistungen von Universitätsdozenten / wissenschaftlichen Mitarbeitern	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Abschluss eines Forschungsvertrages (Auftragsforschung)	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	
	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Gemeinsame Forschungsprojekte / Drittmit-Projekte (Kooperationsverträge)	Wissenschaftliche Einrichtungen insgesamt 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>



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2. Formen und Bewertung der Zusammenarbeit mit wissenschaftlichen Einrichtungen insgesamt und der Humboldt-Universität (HUB) im Speziellen im Wissenschafts- und Technologiepark Adlershof (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)

	Humboldt-Universität (HUB)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Gemeinsame Publikationen	Wissenschaftliche Einrichtungen insgesamt	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Gemeinsame Patente	Wissenschaftliche Einrichtungen insgesamt	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Unterstützung bei der Entwicklung von Prototypen durch Hochschul- und/oder außeruniversitäre Forschungseinrichtungen	Wissenschaftliche Einrichtungen insgesamt	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
	Humboldt-Universität (HUB)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)		1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Bestehen Kontakte / Kooperationen zu weiteren Akteuren (u.a. außerhalb des Standortes Adlershof)?

Interaktion jeglicher Art mit anderen Hochschulen und/oder außeruniversitären Forschungseinrichtungen außerhalb vom Technologiepark Adlershof	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
---	--	--------------------------

3. Welche „Kanäle“ und Instrumente sind derzeit für den Transfer von Wissen und Technologien zwischen Wissenschaft und Ihrem Unternehmen im Regelfall verantwortlich und wie bewerten Sie diese (IST-Zustand)? (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)

	Nicht wichtig ----- Sehr wichtig	Nicht zutreffend
	1 2 3 4 5	

Kanäle / Intermediäre (d.h. Einrichtungen, die Kontakte herstellen bzw. Kooperation anbahnen und durchführen)

Persönliche Kontakte und Netzwerke	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
------------------------------------	--	--------------------------



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3. Welche „Kanäle“ und Instrumente sind derzeit für den Transfer von Wissen und Technologien zwischen Wissenschaft und Ihrem Unternehmen im Regelfall verantwortlich und wie bewerten Sie diese (IST-Zustand)? (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)

Kontaktaufnahme durch Leitung der Hochschul- und/oder außeruniversitären Forschungseinrichtungen	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Technologietransferstellen	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Patentvermarktungs- / -verwertungsgesellschaften	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Branchennetzwerke / regionale Netzwerke	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Technologie- und Gründerzentren (Management)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Technologiepark (Management)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Kammern (IHK, HWK), Verbände, Wirtschaftsförderungsgesellschaften etc.	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Instrumente zur Rekrutierung von Studenten und Absolventen

Persönliche Kontakte und Netzwerke	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Summer School (z.B. International Photonics Summer School)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Jobbörsen / Personalvermittlungsmessen	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Informationsveranstaltungen / Events zu Technologie- und Wissenschaftsfeldern für die Öffentlichkeit (z.B. Lange Nacht der Wissenschaften)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Instrumente zur Unterstützung von Unternehmensgründungen

Beratungs- und Coachingleistungen (u.a. Business-Plan, Technologietransfer)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Netzwerkplattformen (u.a. Bildung von Start-up Teams – z.B. Last Tuesday, Wiwex)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>



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3. Welche „Kanäle“ und Instrumente sind derzeit für den Transfer von Wissen und Technologien zwischen Wissenschaft und Ihrem Unternehmen im Regelfall verantwortlich und wie bewerten Sie diese (IST-Zustand)? (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)

Businessplan-Wettbewerbe (z.B. BPW Berlin-Brandenburg)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Instrumente zur Förderung der Vernetzung der Akteure

Persönliche Kontakte und Netzwerke	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Networking im Technologiepark (z.B. Forum Adlershof, OptecBB, ZEMI)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Kongresse, Messen im Technologiepark (z.B. microsys Berlin)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Virtuelle Kontaktplattformen (z.B. TSB Transfercafé)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonder-Professuren / Stiftungsprofessuren	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
FuE-Marketing (z.B. WISTA-MG Website und Broschüren Adlershof)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Förderprogramme / Finanzierung für die Zusammenarbeit von Wirtschaft und Wissenschaft

Förderprogramme / Stipendien zur Beschäftigung von Wissenschaftlern (u.a. Doktoranden) und Hochschulabsolventen in Unternehmen (z.B. Innovationsassistent)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Förderprogramme für technologieorientierte Existenzgründungen / Ausgründungen aus Hochschulen und außeruniversitären Forschungseinrichtungen (z.B. EXIST)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Förderprogramme für gemeinsame Forschungsprojekte von Unternehmen mit außeruniversitären Forschungseinrichtungen und Hochschulen (z.B. ProFIT, TransferBO-NUS, ZIM)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>



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3. Welche „Kanäle“ und Instrumente sind derzeit für den Transfer von Wissen und Technologien zwischen Wissenschaft und Ihrem Unternehmen im Regelfall verantwortlich und wie bewerten Sie diese (IST-Zustand)? (Bitte bewerten Sie auf einer Skala von 1 – 5; wobei 1 = unwichtig und 5 = sehr wichtig)

Venture Capital / Business Angels	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Soziale Infrastruktur im Technologiepark

Soziale Dienstleistungen (z.B. Kindergarten)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Weitere Dienstleistungen (z.B. medizinische Versorgung, Einzelhandel, Gastronomie, Freizeit- und Kultureinrichtungen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Wohninfrastruktur und weitere Services (z.B. Sprachkurse) für Gast- bzw. ausländische Wissenschaftler (z.B. IGAFa)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Sonstiges (bitte nennen)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Politische Rahmenbedingungen (Decision-making):

3.2 Sind Ihnen die Innovationsstrategie des Landes Berlin und die dazugehörigen Kompetenzfelder bekannt?

Ja ☐ Nein ☐

3.3 Ist Ihnen die Transfer-Allianz – das Berliner Bündnis für Innovation (Fortsetzung des Runden Tisches Wirtschaft - Wissenschaft) bekannt?

Ja ☐ Nein ☐



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2 INTERVIEWLEITFADEN (EXPERTENINTERVIEW)

Erwartungen und Bedürfnisse

1. Mit welchen wissenschaftlichen Einrichtungen (HUB Nawi, außeruniversitäre FuE-Einrichtungen) am Standort Adlershof haben Sie Kooperationen, und wie gestalten sich Ihre Netzwerke (Form, räumliche Aspekte)? Wie sind Ihre Kooperationen insgesamt räumlich gelagert (lokal, regional, international)?
2. Sind Sie in der Zukunft an einer intensiveren Zusammenarbeit mit Hochschul- und/oder außeruniversitären Forschungseinrichtungen im Wissenschafts- und Technologiepark Adlershof interessiert?
3. Was erwarten Sie von einer Zusammenarbeit mit Hochschul- und/oder außeruniversitären Forschungseinrichtungen im Wissenschafts- und Technologiepark Adlershof?
 - a. Wie sollten Kooperationen zwischen Wirtschaft (technologieorientierte Branchen) und Wissenschaft aus Ihrer Sicht gestaltet sein?
 - b. Wie findet der Austausch / Transfer von Wissen mit Ihren wissenschaftlichen Kooperationspartnern im Moment statt?
4. Welche Leistungen / Instrumente sollten zukünftig zusätzlich angeboten werden, um die Zusammenarbeit von Unternehmen mit Hochschulen und außeruniversitären Forschungseinrichtungen zu verstärken?

Barrieren und Hindernisse

5. Welche Barrieren bestehen aus Ihrer Sicht hinsichtlich der Zusammenarbeit mit Hochschul- und/oder außeruniversitären Forschungseinrichtungen am Standort Adlershof?
6. Haben Sie abschließend Anregungen oder Anmerkungen zum Thema, die bisher nicht zur Sprache gekommen sind?

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Figure A2: Cover letter, questionnaire, interview topic guide for interviews at Cartuja science park (Know-Man project)





1. CUESTIONARIO

FECHA:

EMPRESA:

ENTREVISTADO (Cargo / Departamento):

Sección A: Sobre la empresa

1	Cuando y donde se creó la empresa? Fecha de constitución: (MM/YYYY): _____ Localización: _____
1a	Cuando se instaló en el Parque Científico y Tecnológico Cartuja? (MM/YYYY) _____
2	Cuántos empleados tiene su empresa en total? Y específicamente, personal a tiempo completo? Personal dedicado a I+D? _____
3	Cual fue aproximadamente la facturación de la empresa el último año (2009)? <input type="checkbox"/> ≤ 2 Mill. € <input type="checkbox"/> Entre 2 y 10 Mill. € <input type="checkbox"/> Entre 10 y 50 Mill. € <input type="checkbox"/> Mas de 50 Mill. € <input type="checkbox"/> No se especifica
4	Cual fue el porcentaje de Gastos en I+D en relación al total de facturación en 2009? <input type="checkbox"/> No se realizan actividades de I+D <input type="checkbox"/> Hasta el 1 % <input type="checkbox"/> 1 - 2 % <input type="checkbox"/> 2 - 3,5 % <input type="checkbox"/> 3,5 - 8,5 % <input type="checkbox"/> Mas del 8,5 % <input type="checkbox"/> No se especifica
5	Cuales son las principales actividades de su empresa? (Se pueden elegir varias opciones) <input type="checkbox"/> Producción y Fabricación <input type="checkbox"/> Educación / Formación <input type="checkbox"/> Investigación y Desarrollo <input type="checkbox"/> Ventas y Distribución <input type="checkbox"/> Servicios empresariales / Consultoría <input type="checkbox"/> Otros (por favor, especificar) _____
6	A qué sector o sectores pertenece su empresa? (Multiple choices may apply.)



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<input type="checkbox"/> TIC	<input type="checkbox"/> Biotecnología
<input type="checkbox"/> Ingeniería Aplicada	<input type="checkbox"/> Energía y Medioambiente
<input type="checkbox"/> Servicios diversos	<input type="checkbox"/> Audiovisual
<input type="checkbox"/> Otros (por favor especificar) _____	
7	Cómo puede clasificarse su empresa? <input type="checkbox"/> Spin-off de Universidad (por favor especificar la Universidad) _____ <input type="checkbox"/> Spin-off de Centro de I+D (por favor especificar el Centro) _____ <input type="checkbox"/> Spin-off de otra empresa (por favor especificar la empresa) _____ <input type="checkbox"/> Empresa independiente de otras instituciones o empresas <input type="checkbox"/> Empresa filial / Delegación

Sección B: Formas y Evaluación de las interrelaciones con instituciones científicas y de investigación

1. Cómo evalúa el alcance de las relaciones de su empresa con instituciones científicas y de investigación en general en los últimos 3 años? (Por favor evaluar en una escala del 0 - 5; donde 1 = relaciones puntuales y aisladas y 5 = relaciones continuas y de larga duración)						
Sin relación <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>						
2. Formas y evaluación de la cooperación con entidades científicas y de investigación del PCT Cartuja (Por favor, evaluar en una escala del 1 - 5; donde 1 = Muy importante y 5 = No importante)						
No importante ----- Muy importante						No aplica
1 2 3 4 5						
Relaciones personales (p.e. profesores, investigadores, etc.)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	<input type="checkbox"/>
Acceso a infraestructura científica (e.g. laboratorios y instalaciones para pruebas) y bibliografía especializada (e.g. bibliotecas científicas, trabajos de investigación, etc.)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	<input type="checkbox"/>
Asistencia a seminarios, conferencias, cursos, etc.	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	<input type="checkbox"/>



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Contratación de estudiantes y personal investigador en proyectos (e.g. becas, proyectos fin de carrera y tesis, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Intercambio de personal científico y de investigación	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Formación específica para el personal de la empresa	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Contratación para servicios de consultoría	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Contratos de Investigación	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Investigación conjunta	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Publicaciones conjuntas	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Patentes conjuntas	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Apoyo para desarrollo de prototipos	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Relaciones existentes con otras entidades (fuera del PCT Cartuja)?		
Relaciones con otras universidades e instituciones no universitarias de investigación fuera del PCT Cartuja	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

3.1 Qué instrumentos e intermediarios son los más utilizados para la transferencia de tecnología entre su empresa y el mundo científico? Cómo evalúa sus efectividad?			
(Por favor, evaluar en una escala del 1 – 5; donde 5=Muy importante y 1=No importante)			
No importante ----- Muy importante			No aplica
1 2 3 4 5			
Instrumentos e Intermediarios (p.e. Instituciones que inician los contactos y facilitan la cooperación)			
Contactos personales	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>	
Contactos iniciados por las Instituciones Científicas y de Investigación	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>	
Oficinas de Transferencia de Tecnología (OTRI Univ. de Sevilla)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>	
Oficinas de Patentes	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>	



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Redes empresariales regionales	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Entidad gestora de incubadora	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Entidad gestora del Parque	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Agencia IDEA, CTA, CITAndalucía, Cámara de Comercio etc.	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Instrumentos para fomentar la contratación de estudiantes y recién graduados		
Contactos personales con las instituciones científicas	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Ferias de empleo	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Programas de becas (proyectos fin de carrera)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Instrumentos para favorecer el emprendimiento		
Servicios de asistencia y consultoría (p.e. planes de negocio, technology transfer)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Redes e Instituciones de promoción del emprendimiento (p.e. Andalucía Emprende)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Concursos de Planes e Ideas de Negocio (p.e. Creara 50K, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Instrumentos para fomentar el trabajo en red		
Contactos personales con las instituciones científicas	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Encuentros empresariales bilaterales (p.e. CO-PIT, encuentros TT, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Ferias, conferencias (p.e. Expopyme, Innovia, Business TIC, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Plataformas virtuales de trabajo en red	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>



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Actividades / Instrumentos de Marketing especializado en I+D (e.g. páginas web, inventarios científicos, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
<i>Instrumentos de financiación</i>		
Programas de apoyo financiero o becas para la contratación de personal investigador, tecnólogos, etc. (p.e. INNORPORA, Torres Quevedo, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Programas de apoyo a la financiación de empresas de base tecnológica y spin-off (p.e. Programa CAMPUS, Artículo 15 agencia IDEA, NEOTEC, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Programas de apoyo a la financiación de proyectos de I+D conjuntos con la participación de empresas y centros de investigación (p.e. Orden única Agencia IDEA, INNPACTO, Proyectos de Excelencia CEIC, etc.)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Entidades de Capital Riesgo / Business angels	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
<i>Infraestructura social del PCT Cartuja</i>		
Servicios de carácter social (p.e. Guarderías)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Servicios adicionales (p.e. servicios médicos, restaurantes, ocio y cultura)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>
Otros (por favor especificar)	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>	<input type="checkbox"/>

Proceso de Toma de Decisiones

3.2 ¿Conoce la estrategia de innovación de la Junta de Andalucía y los sectores preferentes identificados en el Programa de Incentivos para el Fomento de la Innovación y el Desarrollo Empresarial en Andalucía?

Sí ☐ No ☐

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2. LÍNEAS/ GUIÓN PARA LA ENTREVISTA

Fecha, Lugar:

Empresa:

Entrevistado (Cargo / Departamento):

Expectativas y necesidades

1. ¿Con qué instituciones universitarias y no-universitarias de investigación del PCT Cartuja coopera? ¿Cómo podrían caracterizarse geográficamente las redes de cooperación utilizadas por su empresa (especificar ámbito de cooperación a nivel empresarial y de investigación: local, regional, nacional, europeo, más)?
2. ¿Cree necesario que se fomenten las relaciones continuas y estables entre empresas y centros de investigación del PCT Cartuja en el futuro?
3. ¿Qué espera de estas relaciones con centros de investigación en el PCT Cartuja en el futuro?
 - a. ¿Cómo deberían ser las relaciones entre las empresas y las instituciones científicas?
 - b. ¿Cómo funciona en este momento la cooperación?
4. ¿Qué tipo de servicios cree necesario implementar para mejorar la cooperación entre el sector privado y las instituciones de investigación en el futuro?

Obstáculos

5. Desde su punto de vista, ¿qué tipo de obstáculos siguen existiendo en la relativo a la cooperación Universidad o Centro de Investigación-Empresa en el PCT Cartuja?
6. ¿Quiere hacer algún comentario o aclaración adicional ?

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Table A3: **Measurements of variables (standardized interviews)**

Variables	Possible answers	Type and range of variables
Section 1: Firm characteristics		
Firm's age	Open-ended (subsequent classification into categories by author: ≤ 3 years (2007-2010); 4-5 years (2005-2006); ≥ 5 years (in/before 2004))	Categorical
Firm's duration of residency at STP	Open-ended (subsequent classification into categories by author: ≤ 3 years (2007-2010); 4-5 years (2005-2006); ≥ 5 years (in/before 2004))	Categorical
Firm's turnover in 2009	$\leq \text{€ } 2\text{m}$; $\text{€ } 2\text{-}10\text{m}$; $\text{€ } 10\text{-}50\text{m}$; $\geq \text{€ } 50\text{m}$	Categorical
Firm's employment	Open-ended (subsequent classification into categories by author: < 5 ; 5-9 (micro firm); 10-20; 21-49 (small firm); ≥ 50 (medium-sized firm))	Categorical
R&D expenditures as percentage of the turnover in 2009	No R&D activities; $\leq 3.5\%$; 3.5-8.5%; $\geq 8.5\%$	Categorical
Number of R&D staff	Open-ended (subsequent classification into categories by author (as share of total workforce in %): No R&D activities; $< 10\%$; 10-25%; 26-50%; $> 50\%$)	Categorical
Location of the company in the STP	Based on named company address at STP: Incubator; technology centre/STP owned real estate; own facility/other real estate companies	Nominal
Main activities of the company	Manufacturing/production; R&D; business services; education/training; sales/distribution (multiple choices possible)	Nominal
Industry / technology area of the company	Indicate the industry the company operates in with response categories based on specific STP technology profile: e.g. ICT, biotechnology, optics and photonics, energy, engineering, aerospace	Nominal
Company's background / parent organization	Independently est. firm; university spin-off; R&D centre spin-off; company spin-off; subsidiary/branch office (subsequently classification whether the company has an academic entrepreneurial background: yes; no)	Nominal

Variables	Possible answers	Type and range of variables
Section 2: Importance of general, local and non-local knowledge relations to academia		
Industry-academia relations in the last three years overall	No cooperation - Multi-faceted, long-term relationships	Ordinal (1-6)
Importance of interaction and cooperation (informal, HR related, formal) with co-located academia <ul style="list-style-type: none"> • Personal contacts • Attendance of academic courses • Access to scientific equipment • Recruiting of academic talent • Training for company staff • Exchange of R&D staff • Consulting services • Contract research • Joint research projects • Joint publications • Joint patents • Support in prototype development 	Not important - Very important; N/A if item is not applicable to company	Ordinal (1-5), n/a
Non-local interactive relations to academia overall	Not important - Very important; N/A if item is not applicable to company	Ordinal (1-5), n/a
Section 3: Relevance of internal and external channels for knowledge relations with academia		
Internal sources & channels: <ul style="list-style-type: none"> • Personal relationships • Requests by HEI and R&D institutions 	Not important - Very important; N/A if item is not applicable to company	Ordinal (1-5), n/a
Channels & platforms (KNM): <ul style="list-style-type: none"> • STP-related knowledge marketing • Local networking events • Locally organized conferences • Local and regional intermediaries • Local technology networks • Public support schemes for industry-academia R&D projects 	Not important - Very important; N/A if item is not applicable to company	Ordinal (1-5), n/a

Source: Author

Table A4: **Empirical studies of STPs' regional socio-economic impact (non-exhaustive)**

Author(s)	Case	Method	Examined variables	Findings (ratio of direct vs. indirect/induced employment)
Anttiroiko (2004)	Oulu region	n/a	No. of jobs	1:0.7
Handrich et al. (2008)	STP Berlin-Adlershof	Regional impact / multiplier effects analysis	No. of jobs, gross value added, gross earned income, subsidies	1:0.65
WISTA-MANAGEMENT (2011b)	STP Berlin-Adlershof	Regional impact / multiplier effects analysis	No. of jobs, gross value added, tax revenues	1:1
University of Arizona (2009)	University of Arizona STP	Regional impact / multiplier effects analysis	No. of jobs, output , wages, tax revenues	1:1.18
Holden (2009)	Minatec campus	Regional impact / multiplier effects analysis	No. of jobs	1:2
SPARK Ann Arbor (2016)	SPARK Ann Arbor	Descriptive analysis	No. and growth of jobs, new investments, companies assisted, incubator tenants nurtured, microloans awarded etc.	n/a
HKSTP Corp. (2015)	Hong Kong STPs	Descriptive analysis	No. of jobs, STP resident organizations, incubatees, registered patents, raised seed funding by incubatees etc.	n/a
Cartuja 93 (2011a)	STP Seville-Cartuja	Descriptive analysis	No. and growth of jobs and STP resident organizations, turnover, export activities, human resources, R&D activities etc.	n/a
Shearmur & Doloreux (2000)	17 Canadian STPs	Comparative analysis of urban agglomerations with and without a STP	Growth of employment in high-tech manufacturing and services 1971-1997	n/a

Source: Author

Table A5: Review of empirical studies measuring the effects on STP resident firms (non-exhaustive)

Author	Country	Method	Effects (business performance)	Effects (knowledge spillovers)	Effects (image advantages)
Monck et al. (1988)	UK	<i>Matched pair</i>	- No differences in growth	- More informal contacts and use of academic facilities such as computers and libraries	- Image advantages and enhanced reputation
Quintas et al. (1992)	UK	<i>Matched pair</i>	- No differences in growth	- No differences in links to academia	
Westhead and Storey (1994)	UK	<i>Matched pair</i>	- No differences in growth, survival rate and innovation	- No differences (only concerning use of scientific infrastructure, e.g. library)	- Image advantages and enhanced reputation
Vedovello (1997)	UK	<i>Case study</i>		- Positive effects on links to academia (mostly informal links, followed by human resource links and formal co-operation) - Links are stronger to non-local universities	
Westhead (1997)	UK	<i>Matched pair</i>	- No differences in innovation and survival rate		
Siegel et al. (2003a)	UK	<i>Stochastic frontier estimation</i>	- Positive effects on innovation / R&D productivity (products and patents)		
Löfsten and Lindelöf (2001)	Sweden	<i>OLS</i>	- Positive effects on growth	- No differences in links to academia	
Löfsten and Lindelöf (2002)	Sweden	<i>Matched pair, OLS (10 STPs)</i>	- Positive effects on growth (employment and sales) - No differences regarding technological performance and channelling R&D investments into	- Positive effects on links to academia (low level modes such as access to equipment, informal contacts, recruiting of talent)	

Author	Country	Method	Effects (business performance)	Effects (knowledge spillovers)	Effects (image advantages)
			R&D outputs (e.g. patents)		
Lindelöf and Löfsten (2003)	Sweden	<i>Matched pair</i>	- No differences	- No differences in links to academia	
Lindelöf and Löfsten (2004)	Sweden	<i>Matched pair (10 STPs)</i>	- Positive effects on innovation (product development) - No differences regarding channelling R&D investments into R&D outputs (e.g. patents)	- Positive effects on HEI links (mostly low level modes such as access to equipment, informal contacts, recruiting of talent)	
Ferguson and Olofsson (2004)	Sweden	<i>Matched pair</i>	- Positive effects on survival rate - No differences in growth		- Positive effects on image
Colombo and Delmalstro (2002)	Italy	<i>Matched pair, Tobit</i>	- Positive effects on growth - No differences in innovation	- Positive effects on links to academia (formal links in terms of technical cooperation particularly)	
Phillimore (1999)	Australia	<i>Case study (Western Australian Technology Park)</i>		- Positive effects on links to academia (mostly valued are informal linkages, followed by human resource links and formal links)	
Link and Scott (2003a)	USA	<i>Ordered probit (US science parks)</i>		- Positive effects on HEI links	
Felsenstein (1994)	Israel	<i>Log-linear</i>	- No differences	- Only low level of interaction overall, primarily informally	
Fukugawa (2006)	Japan	<i>Bi probit</i>		- Positive effects on links to academia (joint research)	

Author	Country	Method	Effects (business performance)	Effects (knowledge spillovers)	Effects (image advantages)
Fukugawa (2010)	Japan	<i>Bi probit</i>		- No differences in links to academia	
Squicciarini (2008)	Finland	<i>Matched pair</i>	- Better performance concerning patent activity (i.e. higher likelihood to patent)		
Bakouros et al. (2012)	Greece	<i>Case studies of 3 STPs</i>		- Informal localized business-university ties - Formal links in one STP	
Yang et al. (2009)	Taiwan	<i>Matched pair</i>	- Higher performance regarding R&D outputs - More efficient investments in innovation		
Tel Wal (2008)	France	<i>Longitudinal analysis (Sophia-Antipolis)</i>		- Positive effects on collective learning in local IT cluster - No such effects in local life sciences cluster	

Source: Author based on Fukugawa (2006), Link & Scott (2011) and Vásquez Urriago et al. (2014)

Table A6: **KNM tools examined at Adlershof science park (non-exhaustive)**

<p><i>Knowledge marketing</i></p> <ul style="list-style-type: none"> • STP Adlershof website: The website www.wista.de was launched in 1994, the website www.adlershof.de in 1995. In 2012, more than 500,000 accesses were counted. In 2007 and 2010, respectively, WISTA-MG launched its social media channels on Facebook and Twitter.²⁵⁰ • Adlershof Journal and Adlershof Special: WISTA-MG publishes the monthly magazine Adlershof Journal and other print informational material about on-going activities in the STP's scientific institutions and companies. Adlershof Journal was launched under the name EGA Aktuell in 1993. About 3,000 copies are distributed monthly. Adlershof Special, launched in 2008, is an additional print magazine with several special issues every year about specific technological developments and introductory stories of the STP's resident organizations.²⁵¹
<p><i>Local networking events</i></p> <ul style="list-style-type: none"> • Academic Lunch: This networking event is organized by IGAFA (the association of non-university R&D institutions at the science park) since 2003. It offers a platform for the regular exchange between researchers and technology-oriented companies in Adlershof. It takes place approximately once per month. Since 2003, about 100 events were held.²⁵² • Ladies Lunch: This networking event was launched by IGAFA and WISTA-MG in 2008. It aims to promote networking among businesswomen and female researchers in Adlershof.²⁵³ • Business Lunch: The network Forum Adlershof is the official host of the networking event Business Lunch. Typically, it takes place once a month (without any fixed date). It includes a brief keynote presentation of an invited expert (entrepreneurs, researchers etc.) from resident organizations or other organizations. Usually, members of the Forum Adlershof and IGAFA, but also non-member organizations are invited to this event series.²⁵⁴
<p><i>Locally organized conferences</i></p> <ul style="list-style-type: none"> • PRORA: The conference for X-ray analytics for industrial processes is organized by the Institut für angewandte Photonik (IAP) since 2001. It is held every two years at the Adlershof science park and usually attracts developers, researchers and industry.²⁵⁵

²⁵⁰ Source: Expert interview with WISTA-MG (January 15, 2013).

²⁵¹ Source: Expert interview with WISTA-MG (January 15, 2013).

²⁵² Source: IGAFA (2013a).

²⁵³ Source: IGAFA (2013b).

²⁵⁴ Sources: Know-Man (2011); expert interview with WISTA-MG (January 15, 2013).

²⁵⁵ Source: IAP (2012).

- **microsys-Berlin:** microsys-Berlin, which was established in 2001, is the combined trade show and conference of the micro systems industry (micro-optics and micro-optical systems) of Berlin and Brandenburg. TSB and ZEMI organized the conference every two years. microsys-Berlin aims to showcase the micro systems technology industry (micro-optics and micro-optical systems) of Berlin and Brandenburg. Until 2007, the conference took place four times at the STP Adlershof.²⁵⁶
- **International Photonics Summer School:** This summer school was established in August 2006. It was organized by OptecBB, WISTA-MG and the Department of Physics of the HU-Berlin. In addition to the organizers, a variety of students, researchers, industry professionals, companies and research institutions were involved in the summer school's workshops, presentations and social events. The courses, workshops, presentations etc. covered issues like illumination design and new optical components for the illumination path, as well as scanner and micro display technologies.²⁵⁷

Local technology networks

- **Technologiekreis Adlershof:** Technologiekreis Adlershof is a formal network of ca. 90 technology-based firms and scientific institutions at the Adlershof science park. It was founded in 2003 and pursues the following goals:
 - Representation of interests of the network members concerning the STP's structural and urban development,
 - Fostering of business-to-business and business-to-science linkages,
 - Promotion of localized commercial and technology-based interaction and generation of synergies,
 - Support in the STP's investment promotion strategy to attract new investments at the science park.²⁵⁸
- **OpTecBB:** OpTecBB is the formal network of optical technologies in the Berlin-Brandenburg region. It was established in 2000. The network comprises ca. 80 companies, 30 scientific institutes and selected administrative entities. Accordingly, it represents about one third of the region's firms and scientific institutions in optical technologies. The network aims at strengthening joint innovation projects and commercial activities.²⁵⁹
- **Forum Adlershof:** The network Forum Adlershof was founded in 1999. It includes members from academia and the private sector in the Adlershof science park. Forum Adlershof regularly organizes networking events in cooperation with other local stakeholders and intermediaries, for example, WISTA-MG and IGAFa.²⁶⁰

²⁵⁶ Source: WISTA-MANAGEMENT (2006b, 2013b).

²⁵⁷ Sources: Know-Man (2011); WISTA-MANAGEMENT (2017).

²⁵⁸ Source: Technologiekreis Adlershof (2016a).

²⁵⁹ Source: OpTecBB (2016a).

²⁶⁰ Sources: Know-Man (2011); expert interview with WISTA-MG (January 15, 2013).

Intermediaries (local and regional)

- **WISTA-MANAGEMENT GmbH (WISTA-MG):** WISTA-MG, established in 1994, is the management company of the Adlershof science park. It is a public company, owned by the state of Berlin. Its predecessor organization, Entwicklungsgesellschaft Adlershof mbH (EGA), was founded in 1991. WISTA-MG offers the following services:
 - Science park land and office space management,
 - Management of the technology centres in the defined technology areas,
 - Investment promotion,
 - Start-up support (in cooperation with IZBM GmbH),
 - Business support services (e.g. internationalization, public funds and networking),
 - PR and marketing of the science park,
 - Cooperation with international STPs (e.g. EU, IASP).²⁶¹
- **Humboldt-Innovation GmbH (HI):** HI is the technology transfer office of the Humboldt-Universität zu Berlin (HU-Berlin). It is a 100 % daughter private company of the HU-Berlin, established in 2005. The main activities of HI comprise the assistance in university-industry research projects, spin-off development, as well as marketing and merchandising. HI has offices at two of the three campuses of the HU-Berlin; in the city centre and since 2010 in the vicinity to the campus Berlin-Adlershof (ca. 1km) at the pre-incubator Spin-Off ZONE.²⁶²
- **Berlin Partner GmbH:** Berlin Partner is the regional development and marketing agency of Berlin. It was founded in 2005, but had several predecessor organizations (BAO BERLIN International GmbH (BAO), Wirtschaftsförderung Berlin GmbH and Partner für Berlin Holding - Gesellschaft für Hauptstadt-Marketing mbH). Berlin Partner is a public-private partnership. Its primary focus is the support of Berlin firms in the fields of start-up and SME promotion, internationalization and innovation. Furthermore, it markets the business location Berlin to German and international investors.²⁶³
- **Technologiestiftung Berlin (TSB):** TSB is the regional innovation agency of Berlin. Its predecessor Technologiestiftung Innovationszentrum Berlin was founded in 1994, which was renamed to TSB in 2006. The predecessor institution TVA opened an office at the Adlershof science park in October 1994. In 2010, the TSB closed it. TSB has the objective to support cooperation and knowledge transfer between regional companies and scientific institutions in order to strengthen specifically SMEs' innovative potential. It provides specific services, for example:
 - Organization of demand-and-supply oriented events in specific fields of science and technology,

²⁶¹ Sources: WISTA-MANAGEMENT (2013c); expert interview with WISTA-MG (January 15, 2013).

²⁶² Sources: Know-Man (2011); Humboldt-Innovation (2013).

²⁶³ Source: Berlin Partner (2013).

- Mapping of regional stakeholders knowledge supply and knowledge demands,
- Individual coaching and knowledge-brokering assistance.²⁶⁴
- **Berlin Chamber of Industry and Commerce (Berlin CIC):** The Berlin CIC was established in 1902. It represents the interests of Berlin companies and provides assistance and specific services in regard to start-up and SME support, expansion and growth, training and vocational education, internationalization, networking and innovation.²⁶⁵

Public support programmes for industry-academia R&D projects

- **ProFIT:** ProFIT is a financial support scheme provided by the Investment Bank Berlin (IBB) since 2004. The support scheme aims to initiate joint R&D and innovation projects of companies and scientific institutions in the state of Berlin. ProFIT comprises two products: 1) non-repayable subsidies of up to € 400,000 (per individual project or project partner) for industrial and experimental R&D activities, as well as 2) loans with below-market interest rates of up to € 3m and max. 80 % of the project volume (duration of max. 8 years) for joint activities related to experimental R&D, development of production and market preparation.²⁶⁶
- **TransferBONUS:** TransferBONUS, launched in October 2009, is a financial support scheme provided by the IBB. The innovation voucher primarily aims to initiate small cooperation projects between SMEs and scientific institutions in the state of Berlin. The first option subsidizes joint projects dedicated to product or process innovation. The funding rate is 100% with a max. project volume of € 3,000. The second option supports joint projects with a max. amount of € 15,000. Here, the funding rate is 70%.²⁶⁷
- **ZIM:** ZIM (Zentrales Innovationsprogramm Mittelstand) is a national programme, provided by the BMWi, to support R&D cooperation of technology-oriented SMEs und scientific institutions. ZIM started in July 2008. The programme provides funding for individual R&D projects by companies, joint R&D projects of companies and scientific institutions, and cooperation networks (incl. network management and related joint R&D projects). EuroNorm GmbH and VDI/VDE-IT GmbH are the managing bodies of the programme on behalf of BMWi.²⁶⁸
- **EU Framework Programme for Research and Innovation:** The Framework Programmes (FP) are funding programmes created and coordinated by the European Commission to support research and innovation in the EU, promoting the European Research Area (ERA). The first framework programme (FP) for research was launched in 1984. Since then, eight FPs have been implemented in total. The 7th FP ran from 2007 to 2013. Horizon 2020 is the recent FP, launched in 2014. For each

²⁶⁴ Sources: Know-Man (2011); expert interview with WISTA-MG (January 15, 2013).

²⁶⁵ Source: IHK Berlin (2013).

²⁶⁶ Sources: Investitionsbank Berlin (2009); expert interview with Investitionsbank Berlin (February 18, 2013).

²⁶⁷ Sources: Know-Man (2011); Investitionsbank Berlin (2013).

²⁶⁸ Source: Federal Ministry of Economic Affairs and Energy (BMWi) (2013).

funding period, specific objectives and alignments of the diverse funding streams are defined.²⁶⁹

Table A7: **KNM tools examined at Cartuja science park (non-exhaustive)**

Knowledge marketing

- **STP Cartuja website:** The science park's website, hosted by Cartuja 93, provides information about the site's history and development, and related infrastructure and facilities. Furthermore, it informs about on-going projects and activities of Cartuja 93. Cartuja 93 launched its social media channels on Facebook and Twitter in June and September 2012, respectively.²⁷⁰
- **Cartuja Innova magazine and Cartuja 93 Scientific and Technological Offer Guide:** Cartuja 93 S.A. provides various print materials to inform about the competencies of the resident organizations and on-going activities. Examples are Cartuja Innova, a regular magazine that was first issued in 1999. In addition, the Scientific and Technological Offer Guide, published in 2006 and updated in 2008/2009, provides information by distinct research areas about the research groups located in the science park and additional research centres in Seville.²⁷¹

Local networking events

- **Cartuja 93 Working Breakfast:** The Cartuja 93 working breakfast is a regular networking event at the Cartuja science park since 2007. It is a monthly meeting that focuses on distinct topics with up to 20 participants from businesses and academia. Usually, the event started with a brief keynote presentation of a local entrepreneur or researcher. Since 2010, the event has only taken place very occasionally.²⁷²
- **COPIT:** COPIT is a programme to spur cooperation between entities in industrial parks and science parks. It is financed by the Spanish Ministry of Industry, Tourism and Commerce. The Cartuja science park has participated in the programme for Andalusia from 2009 to 2011. Cartuja 93 was in charge of the organization at the science park. Also, various other organizations have been involved, for example, the Cartuja-based university Escuela de Organización Industrial (EOI).²⁷³
- **TTAndalucía:** TTAndalucía is a networking event, which was initiated by Agency IDEA, CITAndalucía, RETA and the network of Andalusian university TTO in 2007. TTAndalucía is a one-day networking and matchmaking event specialized on certain areas of technology (e.g. agrifood, biotech, energy and environment, transport and

²⁶⁹ Source: European Commission (2014).

²⁷⁰ Sources: Expert interview with Cartuja 93 (September 24, 2012); Cartuja 93 (2013b).

²⁷¹ Sources: Cartuja 93 (2006, 2010d).

²⁷² Sources: Know-Man (2011); Cartuja 93 (2011b); expert interview with Cartuja 93 (April 4, 2011).

²⁷³ Sources: Cartuja 93 (2010b); expert interview with Cartuja 93 (April 4, 2011).

aerospace, and ICT), where research groups and companies gather and arrange bilateral meetings to get to know each other and discuss potential cooperation. Typically, the events are linked to specific trade shows and other kind of industry- gatherings. From 2007 to 2010, 19 technology transfer events TT Andalucía were organized. In this time period, more than 3,260 successful meetings were arranged and more than 60 cooperation agreements were counted.²⁷⁴

Locally organized conferences

- **Foro Innovatec:** The conference Foro Innovatec, set up in a cooperation of Cartuja 93 and Cajasol in 2001, aims to serve as a platform for the active exchange of new ideas in technology, science, society and politics in Andalusia. A joint dinner afterwards aims to enable further discussion among diverse participants.²⁷⁵
- **INNOVÍA Andalucía:** INNOVÍA Andalucía is a one-day conference, organized by the Regional government of Andalusia (Dept. of Innovation, Sciences and Businesses) and RETA. The event was introduced in 2007. It includes round tables, bilateral meetings and more informal networking opportunities. The target groups are innovative companies operating in various technology fields that have difficulties to access knowledge carriers and innovators such as scientific institutions. The event takes place multiple times a year in various locations in Andalusia, including the STP Cartuja.²⁷⁶
- **EXPOPYME:** EXPOPYME is an annual conference for SMEs, scientific institutions, industry networks and SME supporting institutions. It was established in 2006 and takes place in different cities and autonomous communities in Spain in order to outreach to a variety of attendees each meeting. The event includes talks, expositions and demo spaces. In 2010 and 2011, EXPOPYME took place at the STP Cartuja.²⁷⁷
- **Business TIC:** Business TIC, established in 2008, is a predominantly business-to-business meeting of the ICT sector in Andalusia and Spain. Additionally, R&D institutions, financial institutions, VC providers and public institutions involved in the ICT sector participate in the event. The ICT industry associations ETICOM and AMETIC organize the event. Among others, the conference took place at the STP Cartuja in 2009.²⁷⁸

Local technology networks

- **Círculo de Empresarios de Cartuja:** Círculo de Empresarios de Cartuja is a formal network of ca. 70 firms, scientific institutions and public institutions at the Cartuja science park. It was founded in 2001. The network pursues the following goals:

²⁷⁴ Sources: Know-Man (2011); Agency of Innovation and Development of Andalusia (2011); Junta de Andalucía, Andalusian Agency of Knowledge (2013a).

²⁷⁵ Source: Cartuja 93 (2010b).

²⁷⁶ Source: Junta de Andalucía, Andalucía Emrende (2013c).

²⁷⁷ Source: EXPOPYME Spain (2013).

²⁷⁸ Source: Cartuja 93 (2010b).

- Promotion of commercial and innovation-related linkages between resident businesses and other organizations through mutual activities,
- Organization of networking events,
- Supporting the publication and dissemination of related reports,
- Participation in congresses, trade shows and other business events,
- Promotion of commercial and R&D-based collaboration with national and international organizations.²⁷⁹

Intermediaries (local and regional)

- **Cartuja 93, S.A.:** Cartuja 93, founded in October 1993, is the management company of the Cartuja science park. The company is a public-private partnership. The shareholders include the regional government Junta de Andalucía (51%), Agesa (16,5%), Cajasol (8,65%), Corporación Empresarial Cajasol S.A.U. (8,65%), Ayuntamiento de Sevilla (10%), Diputación Provincial de Sevilla (5%) and the University of Seville (0,19%). The company is responsible for the following tasks:
 - Development and management of the science park's infrastructure,
 - Start-up support (including the management of the Marie Curie incubator),
 - Business support services (e.g. internationalization, public funds, innovation and networking),
 - Communication and marketing of the science park,
 - International projects (e.g. EU projects).²⁸⁰
- **Agency of Innovation and Development of Andalusia (IDEA):** Agency IDEA is the regional development and innovation agency of Andalusia. It was created in 1987 as the Instituto de Fomento de Andalucía (IFA). In 2004, it was established in its current form by the regional government. Agency IDEA is attached to the regional Ministry of Economy, Innovation and Science. It acts as a coordination centre for all forms of public support for innovation. It has an office at the Cartuja science park since 2009. The aims of Agency IDEA are:
 - Strengthening of the region's industrial sector,
 - Increasing the competitiveness, productivity and innovativeness of firms in Andalusia,
 - Developing Andalusia to an attractive region for foreign and domestic investments.²⁸¹
- **Fundación para la Investigación y el Desarrollo de las Tecnologías de la Información en Andalucía (FIDETIA):** FIDETIA, founded in March 2000, is a research and education foundation. It is dedicated to strengthen the knowledge transfer between science and businesses, in particular in the ICT sector. It is situated at the University of Seville's School of Engineering.²⁸²

²⁷⁹ Sources: Círculo de Empresarios de Cartuja. (2016a, 2016b).

²⁸⁰ Source: Cartuja 93 (2013a).

²⁸¹ Sources: PRO-INNO EUROPE, INNO-NETS INNO Partnering Forum (2011); Agency of Innovation and Development of Andalusia (2012).

²⁸² Source: FIDETIA (2012).

- **Innovation and Technology Transfer Centre of Andalusia (CITAndalucía):** CITAndalucía, launched in 2002, is a governmental agency responsible for the fostering of innovation and technology transfer in Andalusia. It is located in the STP Cartuja. Its goal is to support industry-academia technology transfer activities to promote technological development in Andalusia through the organization of technology transfer events and individual knowledge-brokering assistance. CITAndalucía participates actively in the Innovation Relay Centre Network of the European Union. In 2011, it was integrated into the newly formed Andalusian Agency of Knowledge (AAK).²⁸³
- **Corporación Tecnológica de Andalucía (CTA):** CTA, founded in 2005, is a private foundation and focuses on the promotion of cooperation between science and the private sector in the region. The regional government of Andalusia supports CTA. CTA is located in the STP Cartuja.²⁸⁴
- **Andalusian Technology Network (RETA):** RETA is a private, non-profit organization. It was established in April 2005 and aims to promote innovation and technological development in the technology parks in Andalusia.²⁸⁵
- **Secretary of Knowledge Transfer and Entrepreneurship (STCE):** STCE (formerly Oficina de Transferencia de Resultados de Investigación (OTRI)), the TTO of the University of Seville, was established in 1989. STCE's main activities comprise the pillars cooperative research and knowledge transfer, spin-off development, IP protection and exploitation, as well as international programmes.²⁸⁶
- **Seville Chamber of Industry and Commerce (CIC):** The Seville CIC was founded in 1886. It represents the interests of Seville-based companies, mediates between the companies and the public sector, as well as provides services in regard to start and SME support, marketing, HR and training, internationalization, networking as well as innovation.²⁸⁷

Public support programmes for industry-academia R&D projects

- **Orden Única:** Orden Única is a financial support scheme that is coordinated by the Agencia IDEA for the Andalusian government. It was launched in 2005 and aims to develop various types of projects (start-ups, business modernization, competitive business cooperation, as well as R&D cooperation and projects). In regard to industry-academia R&D cooperation, companies have to subcontract a minimum of 15% of the project volume to a public scientific institution in the region. Orden Única is funded via the Incentives Programme for the Promotion of Innovation and Business Development in Andalusia (2008-2013) of the Andalusian government, which receives funding from the Global Grant Innovation Technology Enterprise of Andalusia 2007-2013.

²⁸³ Sources: Cámara de Cuentas de Andalucía (2007); CITAndalucía (2011); Junta de Andalucía, Andalusian Agency of Knowledge (2013b).

²⁸⁴ Source: CTA (2012).

²⁸⁵ Source: RETA (2012).

²⁸⁶ Sources: Universidad de Sevilla, OTRI (2013); Universidad de Sevilla, STCE (2016b).

²⁸⁷ Source: Cámara de Comercio de Sevilla (2012).

The Global Grant is co-financed by the European Regional Development Fund (ERDF).²⁸⁸

- **INNACTO:** INNACTO is a financial support scheme, launched in 2009. It supports joint R&D projects of companies and scientific institutions. Through the joint R&D projects, it aims to propel the creation of innovative spin-offs, as well as to enhance the regional firms' innovative activity, the mobilization of private investment and the creation of new jobs. The minimum project volume is € 700,000. The amount of interest-free loans depends on the planned project volume: less than € 2m (15%), € 2-5m (10%) and more than € 5m (8%). INNACTO is a sub-programme as part of the National Plan of Public and Private Cooperation within the National Framework Programme of Scientific Research and Development and Technological Innovation (2008-2011).²⁸⁹
- **Proyecto de Excelencia CEIC:** Proyecto de Excelencia CEIC is a regional support programme to promote business-to-science R&D projects (in particular concerning applied research). The Andalusian government established it in 2006. The support scheme is part of the Andalusian Plan for R&D and Innovation 2007-2013 (PAIDI).²⁹⁰
- **EU Framework Programme for Research and Innovation:** The Framework Programmes (FP) are funding programmes created and coordinated by the European Commission to support research and innovation in the EU, promoting the European Research Area (ERA). The first framework programme (FP) for research was launched in 1984. Since then, eight FPs have been implemented in total. The 7th FP ran from 2007 to 2013. Horizon 2020 is the recent FP, launched in 2014. For each funding period, specific objectives and alignments of the diverse funding streams are defined.²⁹¹

Table A8: **Comparison of firm characteristics (contingency analysis, chi-square and contingency coefficient), n=52**

	Strong knowledge seekers		Moderate knowledge seekers		Lame knowledge seekers		Total
	absolute	in %	absolute	in %	absolute	in %	
Location							
STP Adlershof	11	42.3	6	23.1	9	34.6	26
STP Cartuja	10	46.1	12	38.5	4	15.4	26
Firm age							

²⁸⁸ Source: Agency of Innovation and Development of Andalusia (2013).

²⁸⁹ Source: Junta de Andalucía (2010).

²⁹⁰ Source: Junta de Andalucía (2008).

²⁹¹ Source: European Commission (2014).

	Strong knowledge seekers		Moderate knowledge seekers		Lame knowledge seekers		Total
	absolute	in %	absolute	in %	absolute	in %	
≤ 3 years (start-ups)	6	33.3	6	33.3	6	33.3	18
> 3 years	15	44.1	12	35.3	7	20.6	34
Firm size (employment)							
< 10 employees (micro firms)	8	41.7	6	25.0	10	33.3	24
≥ 10 employees (small & medium-sized firms)	13	46.4	12	42.9	3	10.7	28
R&D expenditures (as % of turnover)							
≤ 8.5%	7	41.2	6	35.3	4	23.5	17
> 8.5%	14	40.0	12	34.3	9	25.7	35
Duration of STP residency							
≤ 3 years	9	33.3	11	40.7	7	25.9	27
> 3 years	12	48.0	7	28.0	6	24.0	25
Entrepreneurial origin							
Academic spin-offs	7	38.9	9	50.0	2	11.1	18
Others (independently etc. firms, company spin-offs, subsidiaries)	14	41.1	9	26.5	11	35.4	34
Total	21		18		13		

Source: Author

Appendix B

Erschienenene Publikationen

- Schmitz, H.R., & Brinkhoff, S. (2016). Modern STP and AI in a global society, economy and environment – Measuring their multi-faceted impact. 33. *IASP Konferenz 2016 "The Global Mind – linking innovation communities or internationalization, sustainability and growth"* (S. 77-115), 19.-22. September 2016 in Moskau, Russland.
- Neumann, H., & Brinkhoff, S. (2016). Innovation Network Advanced Materials (INAM) – a collective thinking platform to create, develop and produce advanced materials at STP Berlin-Adlershof. 33. *IASP Konferenz 2016 "The Global Mind – linking innovation communities or internationalization, sustainability and growth"* (S. 8-19), 19.-22. September 2016 in Moskau, Russland.
- Schmitz, H.R., & Brinkhoff, S. (2015). Accelerators – Competition, Tools or Growth Engines for STP and AI. 32. *IASP Konferenz 2015 "Science and Technology Parks: New Technologies, New Industries, New Communities"* (S. 59-80), 22.-25. September 2015 in Peking, China.
- Brinkhoff, S., Suwala, L., & Kulke, E. (2015). Managing innovation in 'localities of learning' in Berlin and Seville. In G. Micek *Understanding innovation in emerging economic spaces* (S. 11-32). Farnham: Ashgate.
- Schmidt, S., Brinks, V., & Brinkhoff, S. (2014). Innovation and Creativity Labs in Berlin – Organizing Temporary Spatial Configurations for Innovations. *Zeitschrift für Wirtschaftsgeographie* 58 (4), 232-247.
- Brinkhoff, S., & Kitzmann, R. (2014). Urban dreams and economic realities – Areas of innovation between the demands of the knowledge society and the requirements of innovative industries. 31. *IASP Konferenz 2014 "Science Parks: Where Technology Goes to Work"* (S. 264-279), 19.-22. Oktober 2014 in Doha, Qatar.
- Neumann, H., Brinkhoff, S., Ambrée, P., & Schmitz H.R. (2014). How to attract Multi National Enterprises (MNEs) – Thoughts from a Berlin-based science park about strategies, unique selling propositions and lessons to learn. 31. *IASP Konferenz 2014 "Science Parks: Where Technology Goes to Work"* (S. 102-108), 19.-22. Oktober 2014 in Doha, Qatar.
- Kulke, E., & Brinkhoff, S. (2012). Demand Analysis - Identification of Strategies and Approaches to Linking Companies and Academic Institutions. In C. Minniberger, A. Olechnicka, A. Ploszaj & S. Schmidt *Knowledge Network Management Transfer* (S. 12-27), Warsaw: EUROREG.

Brinkhoff, S., Suwala, L., & Kulke, E. (2012). 'What do you offer?': interlinkages of universities and high-technology companies in science and technology parks in Berlin and Seville. In R. Capello, A. Olechnicka & G. Gorzelak *Universities, Cities and Regions. Loci for Knowledge and Innovation Creation* (S. 121-146), London und New York: Routledge.

Vorträge, in denen das Konzept und die Ergebnisse vorgestellt wurde

2015: STP Adlershof - Making it a Creative City. Kick-off Konferenz Creative Mazowsze: Areas of innovation- creative districts in Poland and Europe", 12. Mai 2015 in Warschau.

2014: Science and Technology Parks creating Economic and Innovation Impact: The example of Berlin-Adlershof science park, Primer Congreso Internacional de Economía, Contabilidad y Administración Crecimiento y desarrollo sostenible en el contexto global, 2.-4. Oktober 2014 in Havanna.

2012: Network management and territorial innovation systems – a comparative analysis of science parks, ICURD/NEURUS Workshop & Seminar, 24.-29. September 2012 in Groningen.

2011: What do you offer? Interlinkages of universities and high-technology companies in science parks in Berlin and Seville, Internationale Konferenz UNICA Cities and their Universities for Creation of Knowledge and Innovation, 26.-27. September 2011 in Warschau.

Abstrakt

Lern- und Innovationsprozesse erfordern den Zugang zu externem Wissen und die Zusammenführung von Wissensbasen verschiedener Akteure und Akteursgruppen (u.a. Wirtschaft, Wissenschaft, öffentliche Verwaltung, sowie weitere Innovationsträger). Wissenschafts- und Technologieparks (WTP) sind in diesem Zusammenhang ein wichtiges Instrument der wissensbasierten Regionalentwicklung, um konkrete Orte des Lernens und von Innovationen zu schaffen. Jedoch die relativ schwache Interaktion zwischen Unternehmen und Wissenschaft in diesen Innovationsräumen sowie die gleichzeitig zunehmend empirisch belegte Relevanz von globalen Wissensflüssen und Innovationsnetzwerken erfordern die Spezifizierung der maßgebenden Einflußfaktoren von Wissensbeziehungen.

Mehrdimensionale Nähe- und Distanzbeziehungen kennzeichnen interorganisatorische Beziehungen des Wissensaustauschs und der Wissensgenerierung. Diese Arbeit analysiert die spezifischen Nähekonstellationen zwischen Unternehmen und wissenschaftlichen Einrichtungen in direkten sowie - durch Wissensnetzwerk-Management systematisch organisiert - in indirekten Wissensbeziehungen. Die konzeptionellen Ansätze der Proximity-Forschung sowie des Wissensmanagements bieten die Grundlage für die empirische Untersuchung der Wissensnetzwerke von Technologiefirmen in den WTP Berlin-Adlershof und Sevilla-Cartuja.

Unterschiedliche Typen von Technologieunternehmen in Hinblick auf die Struktur und räumliche Dimension der Wissensbeziehungen zu Wissenschaft und Forschung stellen ein wesentliches Ergebnis der Arbeit dar. Die Arbeit belegt zudem die Funktion mehrdimensionaler Nähe in den Wissensbeziehungen. Des Weiteren wird die Organisation notwendiger und wichtiger Nahedimensionen durch Instrumente des Wissensnetzwerk-Managements aufgezeigt, um Wissensbeziehungen zu erschließen, zu aktivieren und nutzbar zu machen. Aufbauend auf den Ergebnissen werden Handlungsempfehlungen für das Management von WTP und weiteren räumlichen Innovationssystemen abgeleitet.

Abstract

In the knowledge-based economy, innovation is characterized by a dynamic and interactive learning process involving diverse actors; industry, science, public administration, as well as other entities and sub-systems. In this regard, science and technology parks (STP) have become a prominent instrument of regional governments to create specific localities of learning and innovation. However, empirical evidence increasingly points to rather weak local industry-academia interaction in STPs in specifically and the equivalent importance of local and non-local connections as roots of knowledge diffusion and innovation more generally.

Multi-faceted proximity determines the multi-scalar process of knowledge sourcing and knowledge interaction. This dissertation thesis analyses the specific proximity configurations given in direct ties and organized through knowledge network management (KNM) in STP resident firms' indirect linkages to scientific knowledge sources. The theoretical approaches of the proximity framework and knowledge management provide the analytical framework for the empirical analysis of egocentric knowledge networks to academia of high-technology firms located in the Berlin-Adlershof and Seville-Cartuja science parks.

Based on this theoretical and methodological framework, I identify distinct types of knowledge-seeking STP resident companies in regard to the quality, form and geography of interactive ties to science. Furthermore, the thesis sheds light on the specific proximity configurations relevant in successful industry-academia knowledge relations. Furthermore, it reveals the underlying mechanisms of specific KNM instruments organizing necessary and critical proximities in order to forge, activate and harness knowledge networks on distinct geographical scales. Based on the analysis' findings, specific policy recommendations for the management of STPs and other kinds of territorial innovation systems are developed.

Eidesstaatliche Erklärung

Ich erkläre, dass ich die Dissertation selbstständig und ohne unerlaubte Hilfe angefertigt habe. Ich habe die Dissertation an keiner anderen Universität eingereicht und besitze keinen Doktorgrad im Fach Geografie.

Die Promotionsordnung der Mathematisch-Naturwissenschaftlichen Fakultät vom 17.01.2005 (zuletzt geändert am 13.02.2006), veröffentlicht im Amtlichen Mitteilungsblatt der Humboldt-Universität zu Berlin Nr. 34/2006 ist mir bekannt.

Sascha Brinkhoff

Bonn, den 20. März 2017